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Reducing Manufacturing Costs

AFTER USING PURCHASED POWER FOR 5 YR., METZ FURNITURE CO., OF CHICAGO, INSTALLS PRIVATE PLANT AND REALIZES CONSIDERABLE PROFIT

FOR OF ALL SAD WORDS of tongue or pen,
The saddest are these: 'It might have been.'"

Thus speaks Maud Muller in John Greenleaf Whittier's well-known poem. How much weight this old saying still carries in our modern industrial life is only too often realized by the engineers, managers and owners of those isolated power plants which have been discarded in favor of central-station service. It is many times hard to understand why those in authority will continue to take steps so detrimental to their best interests before thoroughly satisfying themselves that they are really to be the ultimate gainers by doing so.

To one intimately acquainted with the situation, the cause for such occurrences becomes quite apparent, for, in the great majority of cases the fault may be traced directly to the engineer's failing to maintain a detailed account of the cost of operation of his plant, or to the

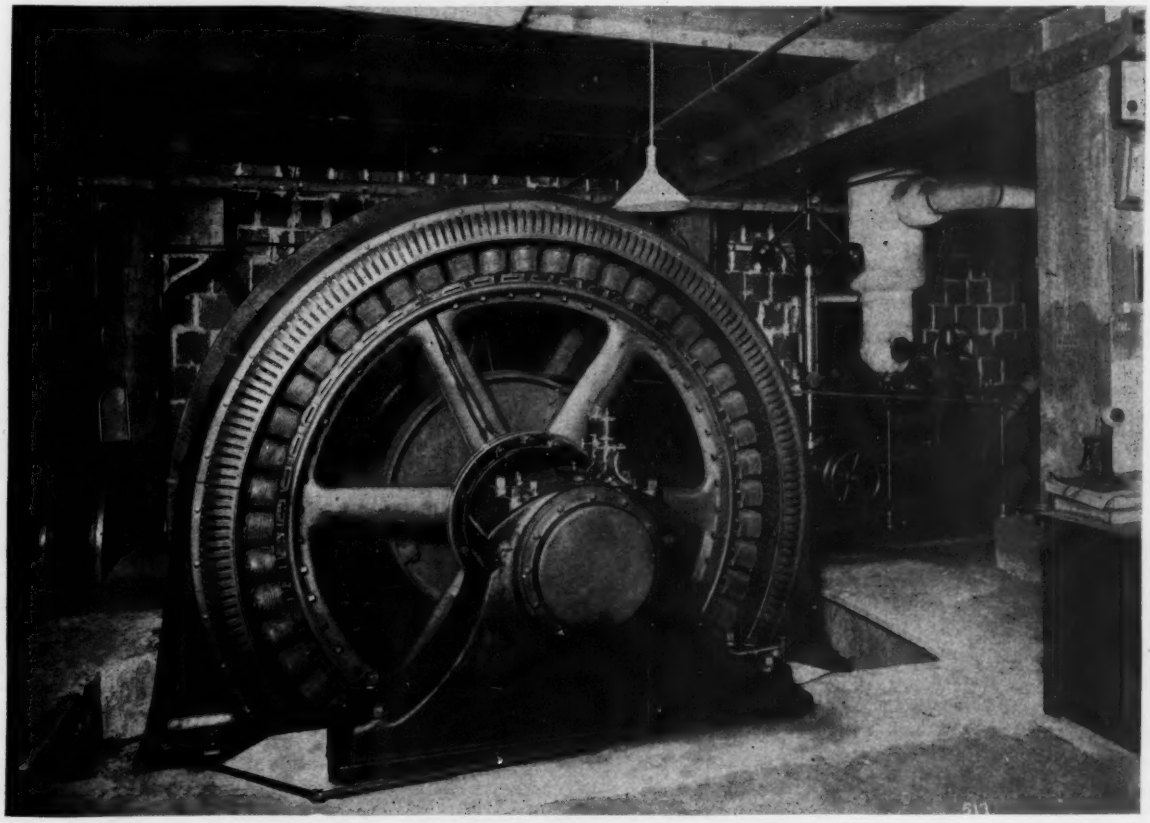


FIG. 1. RECENTLY-INSTALLED GENERATING UNIT

manager or owner who for some reason or other refuses to impart to the engineer any information relative to expenditures made in connection with the plant. From a purely professional point of view, the engineer may be a first-class man, but having failed to pay proper attention to the financial side of his work, or not having had the opportunity to do so, he will, when confronted with the alluring arguments and figures of the central-station representative, find himself unable to produce the actual necessary facts with which to meet them. As a result the employer, even though of the hard-headed business-man type, is often unduly influenced, the plant which in reality has been a paying investment is shut down and dismantled and the engineer compelled either to remain at considerably reduced pay or seek another

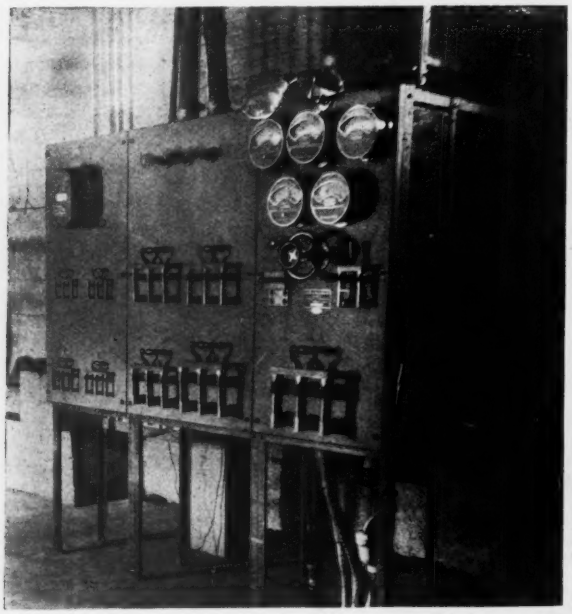


FIG. 2. GENERATOR- AND FEEDER-CONTROL BOARD

position. When this occurs, it is not only the engineer who suffers, but eventually the owner also, who, being tied down for years by an iron-bound contract, may realize his error by the penalty he pays.

On the other hand, spite of claims and statements made by others, it is gratifying to note, due to an awakening on the part of those concerned, that the isolated power plant continues to hold its own. This is evident by the many new installations and old ones revived after their owners have paid for their sad experience. As an example of the benefits derived from the installation of private power plants in manufacturing industries, we cite the case of the Metz Furniture Co., of Chicago, which, after using purchased power for a period of 5 yr., has installed its own plant which it has now operated for a period of nearly a year with considerable profit.

Six years ago, when this company erected its new 6-story factory building at 1465 W. 37th St., arrangements were made to purchase electric energy for light and power. As it was impossible to purchase steam for heating purposes and dry-kiln service, it became necessary to install 2 small low-pressure boilers, the operation and maintenance of which, of course, required the services of an engineer who, with but little extra work, might well have taken charge of a generating unit.

As time passed, the volume of business increased, more machines were added, dry-kilns were enlarged and heating requirements became greater so that not only did the capacity of the boiler plant become inadequate to meet the demands placed upon it, but the monthly statements of the power company called for decidedly larger payments. The necessity of greater boiler capac-

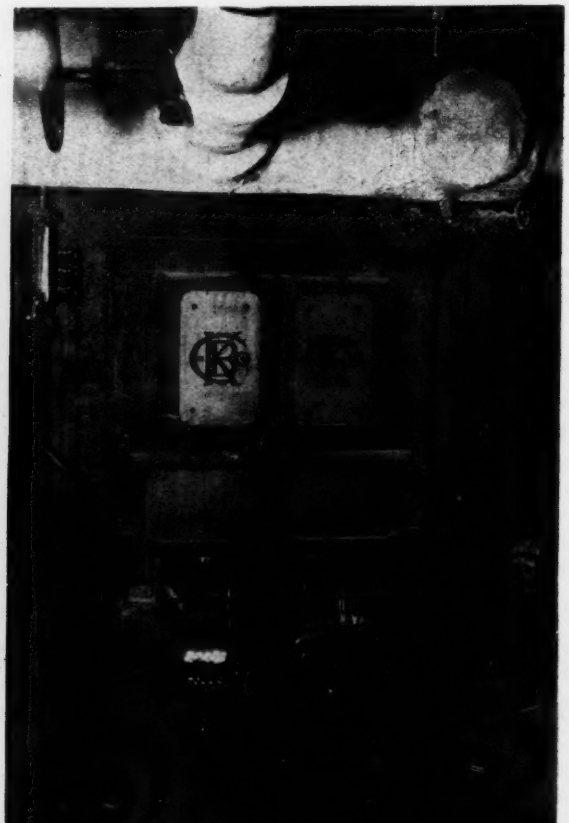


FIG. 3. VIEW IN BOILER ROOM

ity was evident and as the fallacy of purchasing power for an industry of this nature was becoming more apparent from day to day, it was decided to install a plant not only capable of caring for considerably greater heating load than was then being handled, but also of sufficient capacity to operate a steam-driven electric generating set which the company then found necessary to install, in order to reduce its production costs.

After obtaining unbiased views and opinions of various operating and consulting engineers, the early part of 1915 saw contracts closed with the Hooven-Owens-Rentschler Co., of Hamilton, O., for the purchase of a 14 by 30-in., 150-r.p.m., releasing-gear Hamilton-Corliss steam engine, which together with a direct-connected, 200-kv.a., 240-v., 3-phase, 60-cycle Western Electric alternating current generator, and a 12-kw., 120-v., belted exciter

made by the same company was placed in operation during the month of August. In connection with this equipment a 3-panel black marble switchboard for generator and feeder control was also installed.

Current from the generator is delivered to the switchboard bus bars by leads carried in underground conduit, and by means of 8 3-pole, single-throw knife switches is distributed to the various circuits, 4 of which are for power and 4 for light. The voltage on the power circuits is the same as that generated, while that for the lighting service is reduced to 120 v. by means of a 5-kw., 2 to 1 auto-transformer located on the rear of the lighting feeder panel and having an unbalance capacity of 2½ kw.

Service leads are carried to the various floors and departments in iron conduit.

The connected lighting load is at the present time approximately 10 kw., while that on the power circuits is 70 kw. and consists of 44 Crocker-Wheeler 3-phase squirrel-cage induction motors ranging in size from 3 to 30 hp. All of these, except 2 22-hp. motors employed in connection with 2 4000-lb. Kaestner & Hecht freight elevators, are used to operate the various shop machines, arranged for individual and group drive.

In addition to the regular light and power load, numerous electrically-driven hand drills and electrically-heated glue pots are used.

With the factory operating at full capacity, the load on the generator is less than 50 per cent of its rated capacity, thus allowing an increase of at least 100 per cent of the connected load which, according to those in charge, will be capable of caring for 4 times the volume of business now enjoyed by the company.

Steam Generation and Utilization

While the 2 boilers originally installed are still in the plant, all steam for power and heating is at the present time being generated by a Kroeschell combination boiler rated at 180 hp. and operating at pressures ranging from 80 to 110 lb. per sq. in., depending upon the load being carried.

The fuel used consists of a mixture of bituminous screenings and factory refuse, the former being shoveled by hand from cars placed on a siding of the C. J. R. R. into a storage bin having a capacity of approximately 100 tons, and located adjacent to the firing aisle. Kindling is delivered by industrial trucks, while shavings and sawdust are deposited on the floor of the boiler room by chutes connected to a Cyclone blower located on the roof of the building. The proportion of factory waste used varies considerably, depending upon the quantity of stock being cut up and finished, but from carefully maintained cost records it is found that an annual saving of no less than $300 is effected by the use of this refuse.

All firing is done by hand onto McClave-Brooks shaking grates.

During regular operation, steam is delivered by a 6-in. header to the engine, which, according to tests conducted, has an average coal consumption of 3½ lb. per hp.-hr. From the engine it is exhausted into the feed water heater, dry kiln and heating system. When, however, the engine is not in use, live steam is fed to the heating mains and dry kilns through the medium of a bypass and reducing valve.

Auxiliary apparatus located in the engine room consists of a 5 by 7¼ by 10-in. Marsh vacuum pump draining 15,000 sq. ft. of radiating surface, a 9½ by 10 by 10-in. Westinghouse water-jacketed air compressor furnishing air at a pressure of 70 lb. gage for the dry sprinkler system, paint sprayers, rubbing machines and general cleaning purposes, 2 boiler-feed pumps, one a 7 by 4½ by 8-in. Weinman simplex, and the other a 7½ by 5 by 10-in. Warren simplex, and a Hoppes feed water heater rated at 750 hp.

In connection with these various pumps and heater, a novel system of piping is employed whereby all boiler makeup water, taken from the city mains, is first passed through the jacket of the air compressor, then utilized by the vacuum pump for condensing purposes, whence it is delivered to the heater. This allows the absorption of all available heat before being fed to the boilers, which ordinarily is done at a temperature of 215 deg. F.

For domestic water service, a 2100-gal. tank, located on the roof of the building and supplied by a single-stage centrifugal pump direct connected to a 3-hp., single-phase Century motor is employed. This pumping equipment, which is located in the boiler room, is under manual control; but by means of a float electrically-connected to a bank of electric signal lamps, the fireman is notified of high or low water and can stop or start the pump as the requirements may at the time demand.

FIG. 4. TABLE SHOWING TEMPERATURES CARRIED AND TIME REQUIRED FOR THE DRYING OF VARIOUS WOODS

Kind of Wood	Thickness of Stock, Inches	Temperature Carried, Deg. F.	Duration of Drying Period, Days
Beech	5/8	130	12
Chestnut	1	140	10
"	2	140	16
Gum	1	140	14
"	2	130	30
Mahogany	1	140	18
"	2	130	30
Oak (Plain)	1	160	16
" "	2	130	30
Oak (Quarter sawed)	1	160	16
" " "	2	130	30
Walnut	1	140	18
"	2	130	30

Dry Kilns

Throughout the entire year considerable steam is used in heating of the dry kiln, a brick structure built up of 3 units, each 18 by 33 by 14 ft. high and provided with natural-draft fresh-air and outlet stacks. Lumber to be dried is placed on 4-wheel trucks traveling on tracks about 2 ft. above the kiln floor. Below these tracks, at approximately 1 ft. above the floor, are placed the heating coils, consisting of 60 lengths of 29 ft. each, of 1-in. pipes. The temperature maintained depends upon the kind of wood being treated and the thickness of the stock, as shown in the accompanying table.

What Was Gained?

As stated above, the generating unit is operating considerably underload, and as a result, cannot give its maximum economy. The reader may therefore ask how, under such conditions, it is possible that any saving may be realized. Though in operation but a compara-

tively short time, sufficient data is available to show that the saving is beyond expectations and that within a comparatively short time the plant will have more than paid for itself.

From operating records maintained by the chief engineer, we learn that when purchasing power at $0.03 per kw.-hr., the average monthly expense, including coal and labor charges, was $760. Since the generating unit has been installed and considerably more load added, the average monthly expense has been reduced to $328, showing a saving of $432. These figures do not, however, include interest on the investment, depreciation and taxes, which, let us assume, amount to 6, 8 and 1½ per cent respectively. With the original investment, stated to have been somewhat less than $10,000, the interest at the rate of 6 per cent is $600, which, combined with $800 and $150 for depreciation and taxes, results in a total of $1550 per year, or $129.16 per month. Subtracting this from $432, we have an actual net saving of $302.84 per month, at which rate the plant will pay for itself within less than 4 yr.

Credit for the changes made, whereby this great saving is secured, is largely due to P. P. Fisher, who was in personal charge of the design and installation of the new equipment and who at the present time is chief operating engineer.

Standardization of Power Plant Operating Costs*

OUTLINE OF METHOD FOR DETERMINING HOW CLOSE ACTUAL COST IS TO MINIMUM POSSIBLE COST UNDER ANY CIRCUMSTANCES. BY WALTER N. POLAKOV

COST of manufacture of power or any other commodity, being a result of numerous factors involved in production, is in final count the chief criterion upon which the market price, range of use, legislation, future developments, social welfare, etc., are depending. Few, if any, of these questions can be intelligently answered from the knowledge of actual costs, owing to the effect of an unknown factor—degree of perfection of the actual performance. The importance of an accurate knowledge of the meaning and signficance of actual cost data to the financier warrants the development of method whereby a cost report tells:

a. What the power costs.
b. What it should cost.
c. Where the loss has occurred.
d. Why the loss has occurred.

These questions answered, elimination of waste is a comparatively simple engineering problem.

Standardization and predetermination of cost of power production have never before been considered as possible undertakings, and their advantages were thought questionable. Predetermination of operating costs has not been made use of for other than estimates of probable future expenses prepared by promoters or contractors. These estimates are usually based, as is always the case in work of such nature, either on past performances modified by expectations, or on data obtained from actual performance of another plant considered as similar. The accuracy of such estimates depends at least on the following conditions:

a. How reliable were the cost records used.
b. How near the possibilities were realized.
c. How close is the similarity of the equipment of plants under consideration.
d. What effect the location has.
e. What effect the nature of load has.
f. What effect the labor market produces.
g. How completely the future factors were foreseen.

Since there is, however, no assurance that in the *sample plant* the operating methods are perfect, neither is it reasonable to expect that another plant is in every respect identical to the *sample plant*, and the value of such guessed operating cost is highly problematic.

Realizing, on the other hand, that such estimates are inevitably colored by the personal sympathies and prejudices of the estimator, a demand for a class of disinterested counselors has been created. As the financial and not the thermo-dynamic side of the question is more vital in the eyes of the investors, the predetermination of results of power production is often entrusted to public accountants who may or may not be fully equipped to account thoroughly for the influence of such factors as chemical and physical properties of available fuels on efficiency of boilers and furnaces, effect of load and machine factors, water rate of turbines under predominating condition of load, role of power factor, wattless current, phenomena of electric transformation, transmission, drop of voltage in distributing lines and numberless other factors affecting the cost of current either directly or indirectly.

CLASSIFICATION OF EXPENSES

ALL EXPENSES incurred in the course of power production fall under analysis into 2 main groups:

a. Constant (within a certain range) for any output.
b. Variable in some direct proportion with the output.

Expenses that are independent of volume of output are at the same time independent of each other and do not characterize the efficiency of processes performed in the power plant. Their effect on unit cost is represented by a parabolic curve decreasing with the increase of output. They are exemplified by interest on investment, depreciation sinking fund, insurances, management, pay roll (in some cases), taxes, etc.

Expenses that vary with the output of the plant characterize, other conditions being constant, the efficiency of operation, and their elements stand together in dependent sequence. If represented graphically, they show very irregular shaped curves peculiar to each set of equipment. Unit cost has a general tendency to drop with increased output, as the efficiency of boilers, turbines, etc., tends to improve with increased load; yet as with higher degrees of overload, the efficiency decreases, the unit cost rises. With further increase of load when an additional unit is started, the efficiency again begins to improve until their cumulative efficient capacity is exceeded, when the unit cost commences to increase

*From a paper read before the A. S. M. E.

again. Such waves are sometimes very pronounced and generally, throughout the range of the plant's capacity, the number of waves on the unit cost curve is equal to the number of generating units installed. Fuel, water, certain supplies, and in less pronounced dependence, maintenance expenses, belong to this group of expenses, and for the purpose of classification of expense account, it is best to itemize them correspondingly to the steps in which the energy is transformed during the generating process.

The criterion of economy is formulated by the interplay of 3 factors, *time, product* and *cost.* When only one factor varies, its effect on economy can easily be foreseen. Thus greater product, without change of time required or cost, increases the economy. Increase of either time of production or cost of production reduces the economy. Generally, however, all the factors vary simultaneously.*

The graphic method offers an easy means of solving the problem. To determine the *economic limit* reached by continuous increase or decrease of influential elements is by no means an easy problem, but unless it is solved we are in the dark not only as to *what economy can be obtained,* but also *what changes in conditions and methods are essential.* The analysis of the effect of the variations of these elements involved in determination of *maximum limit of economy* can be compared to a determination of the height of the apex of a hill by taking altitude readings on both slopes in one direction and then repeating observations in the crosswise direction.

Standard Costs

It is relatively unimportant whether the maximum limit of economy is determined empirically by rigorous observations, tests and analysis of all influential elements, or calculated from the principal data already available. *It is imperative that such study be made and the economy limit established, as this is the only criterion for judging the actual performance.* Carrying out the analysis of economy limit to its logical conclusion, the standard cost of product is arrived at, and evidently during this investigation, not only are itemized costs of individual partial processes found out, but the conditions and methods whereby standard cost can be attained are established. In other words, *unless the standard costs are established there is no measure of existing losses or exact knowledge how to eliminate them.*

Manifestly, in the course of determination of standard operating cost, such factors as inherent efficiency of equipment, its efficiency under different loads, prices of fuel and supplies, necessary and sufficient number of attendants and their compensation, etc., are already taken into consideration for a given plant. Any deviation observed between the actual operating cost and this standard cost indicates that some of the necessary conditions were not lived up to and, if standardization has been carried out in sufficient detail, it leads directly to the allocation of the loss to operating methods.

On the other hand, any change in the basic data used in determination of the standard cost being known, adjustment of the standard cost can easily be made before the blame is put at the door of the operators. The efficiency of the thermo-dynamic process, domineering the operating cost in a power plant, should be made a subject of a most thorough investigation to ascertain first the maximum efficiency limit of each partial process, and then the result of their interplay. When this is accomplished, the entire process will be re-studied for the purpose of standardizing methods and adjusting for such a balance of efficiencies of partial processes as will secure the maximum profit or economy from the expenditure of time, energy and money involved. In this, it is sometimes found that the most economical thermal efficiency is somewhat below the maximum obtainable, as the slight additional gain in efficiency necessary to reach the maximum is not warranted by the expenditure required for its attainment. When these limiting conditions are studied and determined, a method can then be defined for each member of the working force, prescribing his duties and the conditions he must maintain to secure the most profitable degree of efficiency.

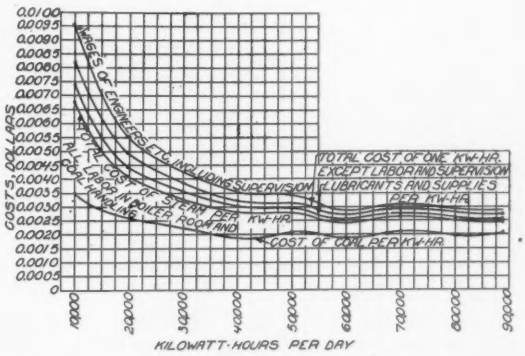


FIG. 1. CURVES SHOWING VARIATION IN STANDARD COSTS OF OPERATION IN A PUBLIC UTILITY CENTRAL STATION

Upon the conclusion of these studies, the best efficiency of each unit and combination of units being known for any load, the standard cost for any output in a given time unit can be conveniently represented in graphical form.

The principles of determining the standard cost of maintenance and upkeep of the plant and equipment are substantially the same; the method of study, however, is somewhat different. It involves a study of design and construction of all elements of equipment; minute records of their service and cost of maintenance may lead to a modification of design, use of cheaper renewable parts, etc. Next, the standardization of supplies, beginning in the laboratory and followed by actual service tests, helps to determine not alone the purchase price, but the lowest service cost. Finally, time studies embracing schedules for inspection, routes for maintenance men, standardization of tools, motions, methods, etc., conclude the investigation. The criterion is, of course, not the wages of the employe, but freedom from accidents, breakdowns and the lowest attainable cost of upkeep per unit of the plant's output. It is evident that there may not be any theoretically certain standard cost of

*The equation of economy criterion $e = P \div ct$ can be made for any influential element n, and the increase of economy of unit increase of n, if differentiated, is

$$\frac{P}{ct} = \left(\frac{P'n}{P} + \frac{C'n}{C} + \frac{t'n}{t}\right)$$

all elements essentially positive. Such a general study can be made with respect to economy if more than one influential element is involved as simultaneous equations for each.

maintenance, but an empirical standard thus developed is generally but a fraction of the best actual records of the past.

Curves of Standard Costs

Upon conclusion of this double analysis of the maximum economy obtainable, the graphs of standard cost of power production may be drawn. Curves may be conveniently arranged in the co-ordinates of cost C and product per unit of time $P \div t$ (output). It will then be noted that the time element is one of the most influential factors in power economy. Whereas in some cases, where the number of generating units is large, the coal-rate per unit of output remains fairly flat and the other items of cost reduce rapidly with increased production per unit of time, in other cases the standard cost of fuel also decreases as the time during which a certain output is produced is reduced. Figures 1 and 2 represent curves of standard operating costs. It is evident that any number of curves may be plotted following the above method, each curve representing an itemized standard cost according to the adopted classification. Figure 1 is thus prepared for a medium size public utility central station. It shows the variations of standard costs of coal, boiler room labor, water, supplies, over-

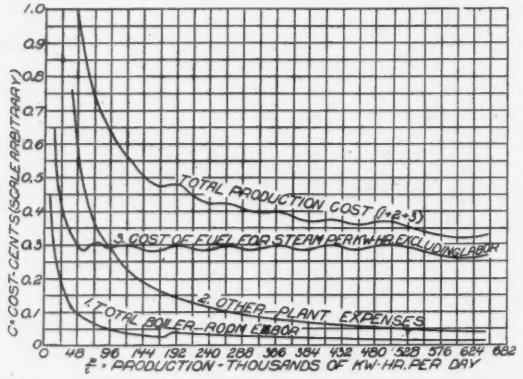


FIG. 2. VARIATION IN STANDARD COSTS OF POWER PRODUCTION AT AN ELECTRIFIED RAILWAY CENTRAL PLANT

head charges, engineers and supervision per kilowatt-hour at various monthly outputs. The cost scale does not show, however, the actual standard. This plant comprises 4 600-hp. boilers and 3 turbo generators, one of 2500 kv.a. and 2 500 kv.a. rating; it operates 24 hr. per day, 7 days a week.

From this diagram it appears that the cost of coal per kilowatt-hour is lowest when the output of the plant is approximately 1,900,000 kw.-hr. per month. Further increase of output coincides with the increased cost for fuel required, due to the characteristic of boilers and turbines that they lose in their efficiency at higher rates of driving. Again, costs of labor, supplies, pro-rate overhead charges, etc., per kilowatt-hour, which drop more rapidly than the cost of fuel rises, offset the difference and render monthly output more desirable economically. Even there, however, we meet a limit when at the rate of 2,200,000 kw.-hr. per month the unit cost becomes higher than it was at the lower output of 1,900,000 kw.-hr. per month.

Figure 2 illustrates a few characteristic curves of standard cost per kilowatt-hour for various rates of output of a large central station feeding the lines of an electrified trunk railroad. The plurality of waves on the fuel cost curve, etc., is explained elsewhere in this paper and the tendency of total standard cost to go steadily downward with increase of the output rate is due to the plurality of generating units.

Use of Standard Cost Curves

Practical use of such predetermined costs can be made extremely simple by the use of these graphs. For busy executives or owners, the entire cost record visualized by graphical representations of the items of account is found very convenient. An example of such a graph is seen in Fig. 3, wherein the actual unit cost and the standard unit cost are plotted to the same scale, the deviation of one from the other suggesting at a glance the degree of perfection of the performance. The total expense curve and the cumulative expense curve may be shown on the same graph to a suitable scale; the latter curve is found very serviceable for comparing these items with the appropriation made. A cost system kept on a card file in this manner will represent clearly in any desired detail for any length of time at any period:

a. How much was spent.
b. How much each unit of output cost.
c. How much it should have cost.
d. What the fluctuations of expenses and unit cost are.
e. What the fluctuations of efficiency are.
f. How close the actual amount spent in any time is to the appropriation.

The accuracy of such graphic records is sufficient for most practical uses and references, as it allows the interpolation of unit costs to 0.001 of a cent. If the exact total of expenditure is wanted it can be had at any time from the book records, whereas the use of books and figures exclusively lacks the comprehensiveness and visual instructive value of graphs.

Any comparison of production costs of various plants may now be made in a different light. By comparing standard costs of one plant with those of another, one gains the knowledge of how much cheaper the power can be produced in one plant than in another, due to its various physical advantages, corrections for load and output all being automatic. Again, by comparing how near the actual cost of one plant is to its standard cost with the difference between actual and standard cost of another plant, one has at once a measure of quality of methods and management. Thus, referring to our Figs. 1 and 2, the actual cost per kilowatt-hour of .35 cent in one plant means a worse operating efficiency than .48 cent in another plant under another load condition. Yet without such accurately predetermined standard costs that are individual for each plant and condition of load. no correct comparison is possible, and conclusions from a mere study of accountants' figures are apt to be grossly in error.

Standardization of Protective Charges

In the above discussion of standard cost we left out of consideration, however, a very important feature—namely, fixed charges borne by the plant. It is a very common policy to install in power plants considerable spare equipment, partly as a protection against possible breakdown and partly to take care of high peak loads

In both cases, it would not be logical to adulterate production costs by the addition of all overhead charges incident to this idle equipment. If all charges due to policy, over-equipment, protection, spare units, new business anticipation and similar allied items are accounted where they belong—not against the operation—the cost of producing the current will appear constant unless prices of fuel, supplies, wages, etc., are changed or methods of management are not uniform.

Inasmuch as the spare equipment has a function identical to a stand-by plant at some distant point of transmission line or a breakdown emergency connection with a power company nearby, it seems entirely proper to segregate this portion of charges and treat it in the same manner as the bills of an emergency contract, i. e., to carry the cost on a separate business account. The parallel between a breakdown connection contract and a plant's own breakdown reserve is apparent, yet it is only too often that the same concern, charging the bills on such a contract against the general business or protection account, insists that the power department shall absorb separate account, the excessive charge against the stand-by equipment, both for fixed charges and running expense, would produce a stimulus for the new business, or commercial, or transportation departments to secure additional load. It is a quite common condition that these departments are not fully aware of the reserve capacity of the plant or plants or, on the contrary, secure more load than it is safe to carry permanently or until an additional generating equipment is provided. *Standard* cost of protective policy would act in all such cases as a gage on a tank of certain capacity with outlet and inlet valves subject to continuous adjustments. In other words, *the new business departments should at all times know the ratio between ideal protective costs* and actual cost of carrying the unutilized portion of power generating equipment.

Comparison of Costs and Efficiencies

The cost system developed along the lines discussed will not only afford a means for clear understanding of operating and managerial problems, but offer a basis

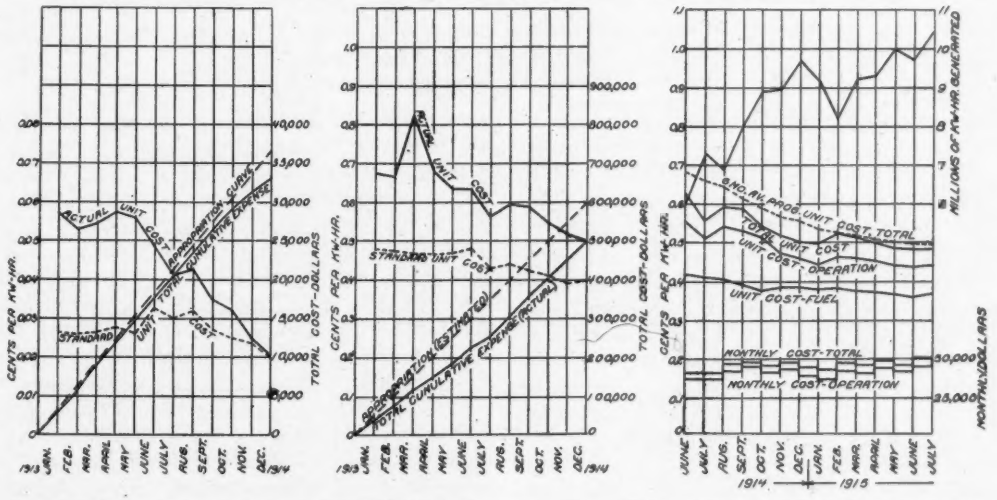


FIG. 3. VISUALIZED RECORDS OF THE ENTIRE COST OF POWER PLANT OPERATION IN WHICH THE ACTUAL UNIT COST AND THE STANDARD UNIT COST ARE PLOTTED TO THE SAME SCALE

in its operating account all expenses accrued in the reserve plant or any part thereof.

The degree of safety and protection from interruptions with which it may be desired to maintain the service is dictated by the general policy of the concern; similarly, the decision to keep a stand-by station in readiness to go into service at a moment's notice or the policy of keeping within the central station a certain number of boilers banked, turbines warmed up and generators phased, should not obscure the cost and efficiency data pertaining to the generation of power. The expenses incurred in connection with such a *protective service* should not be charged to the operating or production account, but might be arbitrarily standardized, reduced or increased as the business policy might require and be *treated as an independent account.*

If, in the case of a plant built and equipped to produce twice the output it normally carries, fixed charges are dumped together with operation costs, it reflects unfairly on the ability of the superintendent and his operating force; whereas if they were properly charged to a

for cost comparison of different plants. The essentials of knowledge gained through a comparison of actual cost in conjunction with the standard are:

a. Relative supremacy of plants proper
b. Relative advantages of managerial methods
c. Relative extent of preventable losses
d. Relative advantages of prices of materials, etc.

These cannot be found unless there is a comparable basis or scale for comparison, which is offered by standard costs determined for each plant individually, as at least 10 main variables must be accounted for, as follows:

a. Nature of load
b. Character of service
c. Conditions imposed by location
d. Inherent efficiency of equipment
e. Arrangement of equipment, floor plan, etc.
f. Cost-efficiency of fuel and supplies
g. Legal requirements
h. Methods of operation
i. Labor conditions.
j. Methods of compensation for service

Each of these variables being in its turn a product of a plurality of factors, it is manifestly impossible to state, without the aid of carefully worked out standard costs, that the economy of one plant or another is satisfactory, or where and how it can be bettered.

Inasmuch as standard cost cannot be determined without first finding out how the maximum economy can be secured, the process of standardization of costs is also a process of devising the best way for operation and management. Once both methods and results are positively established, costs are but the form of expression of the final result. It is true that the standard cost is influenced by the price of commodities used in the course of generation of power, as well as by some conditions beyond the control of the management and operating engineers, but the adjustment of the standard costs to every change of these factors can be made as simple as the use of a slide rule. Furthermore, a separate account should be kept for such charges as are the part of business policy, so that a division of responsibility between those managing the production and directing the business can be drawn.

As long as costs of production of power come as an unexpected surprise and arouse the curiosity to an extent of comparing them with the preceding month, year, or any other plant's data—the management of such power plants is evidently a very haphazard undertaking, lacking the aim at any definite goal. Without predetermined standards, superintendents and managers will continue to believe that they control the production and owners will remain in a happy ignorance as to how much of their money goes to waste and why. Only after the establishment of standards and ideal costs of production by means of the most rigorous analysis, will cost accounting be of help to engineers, and only then can it be said that the generation of power is directed by management and controlled by engineers.

Efficient Operation of Boiler Rooms

SPECIAL FURACE FOR MIXED COAL; SEMI-YEARLY TEST CONDUCTED; FREQUENCY OF BLOWING DOWN GUIDED BY TEST

IN THIS article we take up the operating features of a plant furnishing electric power for interurban trains. The load is quite variable, but the peaks occur at certain periods of the day which has enabled the operating force to make out a program by which the boilers are operated most efficiently.

There are, in the boiler rooms, 9 900-hp. B. & W. boilers which are suspended from I beams, and each boiler is placed in a separate setting, which is built up of brick with a metal covering with an asbestos insulation between the brick and the metal. Bridge walls, arches and furnace linings are made of fire brick. Baffles are also of fire brick, but a patent asbestos compound is now being tried out in this plant.

The furnace is divided into 2 parts by a fire brick wall, and a system of arches is swung from this wall to the sides of the furnace. Considerable experimenting has been done with the arches in one boiler, the latest arrangement being that shown in the sketch herewith, which has given best results.

HEATING SURFACE PROPORTIONS

EACH BOILER has 4 drums and 9000 sq. ft. of heating surface. Serving this heating surface is a grate surface of 190 sq. ft., making a ratio of 47½ to 1. Each boiler is provided with a superheater located between the first and second passes of the boiler, and having a heating surface of sufficient size to give to the steam a superheat of 120 deg., when the boiler is worked at normal rating. In the last boiler installed the distance from the front of the grate to the heating surface is 86 in., and at the rear the distance is 53 in. The other 8 boilers are arranged with the grate at the front 67 in., and at the rear 60 in. from the heating surface. The baffling of the boiler is the standard 3 pass employed in the B. & W. water tube boilers.

All of the boilers are equipped with hand fired grates, 8 of which are McClave shaking grates, with 20 per cent air space, and 1 is a Grieve pinhole stationary grate with 9 per cent air space. From the first of February to the first of November one boiler is out for internal cleaning and one for external cleaning, which leaves 7 boilers in on the line. During the other 3 months the load is heavier and none of the boilers are given an internal cleaning. During the non-peak loads at night, 3 boilers are banked, and in the daytime during non-peak load 2 boilers are banked. The others are operated at about their full load rating; when the peak load comes on all boilers are thrown in and the capacity runs up to about 150 per cent of the factory rating.

Water columns are placed on each drum of the boilers and the water level is carried at the middle of the gage glass by means of hand regulated valves. The water columns have no alarm features, and their connection to the boilers is the standard employed for this type of boiler. The columns are blown down 3 times a day, and the gage cocks are tried at the same time.

The standard feed line discharge is used with these boilers, one pipe entering each drum through the front head and passing through the steam baffles. Two blowoff connections are made to the mud drum of each boiler, and in the connection is a cock and a blowoff valve; all fittings are of steel. There are no fusible plugs in the boilers.

BLOWING DOWN BOILERS

IN THIS plant the frequency with which the boilers are blown down depends upon the impurities found in the boiler water. Each morning a sample of the boiler water is taken from the water column and tested for salt. When this gets as high as 50 gr. per gal., the boilers are blown down. Make-up feed water comes from the city mains and contains a small amount of scale forming material, but as the condensate taken from the condenser is used for feeding purposes and salt water is used for cooling the condenser, any leaks in the condenser allow the salt water to be fed back into the boiler. For this reason the above tests are made regularly. No compound or treatment for the water is employed.

Each boiler is equipped with 6 safety valves, 4 of which are placed on a short header between the drums and discharge the saturated steam when the pressure reaches 200 lb. or above. The other 2 valves are for the superheated steam and are placed on the pipe leading to the header. These are set to blow at 197 lb. All valves are 3 in. in diameter, and are tried out once a week. When the boilers are down for internal cleaning the valves are taken apart and overhauled and tested before the boiler is put back into service.

The standard method of baffling the steam is employed in these boilers, and dry pipes are installed to insure dry steam delivered to the superheaters.

It is the custom in this plant to run a 24 hr. test of the entire plant twice a year. By this means a close approximation can be made on the amount of coal required per kilowatt-hour delivered to the switchboard. The bonus system of paying the fireman is employed, and the results obtained are said to be highly satisfactory.

with hydraulic pressure, after an internal cleaning before they are put into service.

Once each day the ashes are discharged from the pit which is in the shape of a hopper, into industrial cars in the basement, which carry them outside the plant for disposal. Soot which collects back of the bridge wall is removed through one of the side doors, and mixed with anthracite coal and burned in the furnaces.

It is reported that with the mixture of coal used very little clinker is formed, although before the bituminous coal was mixed with the anthracite the low grade of anthracite caused considerable trouble by the formation of clinkers.

Owing to the use of forced draft and hand regulated dampers the necessity of watching for air leaks is quite imperative. An over amount of air in the flue gases is detected by means of an Orsat CO_2 machine, used frequently about the plant, and whenever air leaks are suspected the setting is gone over with a candle to determine their location.

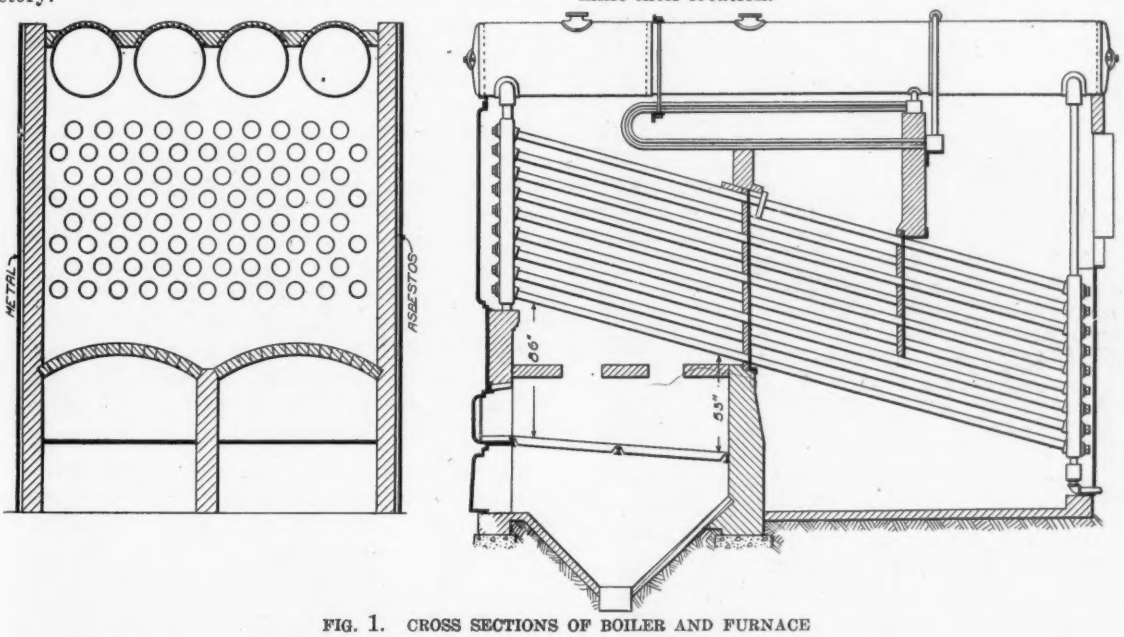


FIG. 1. CROSS SECTIONS OF BOILER AND FURNACE

On one boiler a Venturi meter measures the feed water which it requires, and as this boiler is operated under the same condition as the others in the plant the amount of feed water is closely approximated. There are no means provided for measuring the flow of steam.

Routine for Cleaning

When it is desired to clean a boiler it is dropped at night and the next morning the fire box is cleaned and this is followed by a thorough external cleaning of the boiler tubes and baffles. The boiler is put in shape to be back in operation within 24 hr. from the time it is taken off the line, unless it is intended to give it an internal cleaning, in which case the boiler stands for one day before it is opened, when the turbine is started immediately to work. While the boilers are in operation a steam pipe with a flat nozzle is used every day for blowing the soot off the water tubes. The boilers are always thoroughly overhauled and inspected, as well as tested

Holes in the baffles are detected by means of a light held upon one side with an observer in the dark on the other, and all such leaks are stopped up by means of asbestos cement.

The Mixed Fuel

In this plant a mixed fuel of anthracite and bituminous coal is used, and to determine the proper proportion of the mixture tests were run on one boiler, which is fitted up with the necessary testing apparatus and is called the test boiler. The tests were of 8 hr. duration under as nearly identical conditions as possible to maintain. No. 3 buckwheat anthracite coal was used, and mixed with bituminous slack in the following proportion: 5 per cent bituminous, 7½ per cent, 10 per cent, and a second run of 10 per cent. The results were as follows:

The pounds of steam from and at 212 deg. per lb. of combustible with 5 per cent bituminous coal was 9.1; with 7½ per cent 13; with 10 per cent 11.7, and with

the second run of 10 per cent 10.3 lb. As a result of these tests it was decided to burn a mixture of coal consisting of 92½ per cent anthracite No. 3 Buckwheat and 7½ per cent bituminous, which are mixed by dumping the proper amount of bituminous coal over the top of the carload of anthracite as it is delivered to the plant. The natural mixing of the fuel as it passes from the car to the bunkers is sufficient to give a uniform mixture when the coal is shoveled into the furnace. Smokeless combustion is obtained.

The mixed fuel has a heat value which averages about 12,900 B.t.u., and the volatile constituents make up about 4.61 per cent. A sample of the anthracite coal is taken from each ton and screened to determine the amount of dust in the delivery in order to hold the coal company to their contract to furnish coal of a specified standard or better. The screen is made up of boxes, one

FIG. 2. DRAFT GAGES USED DURING INVESTIGATION WORK ON TEST BOILER

on top of another with the screen at the bottom of each box. The upper screen has holes ¼ in. in diameter and the coal remaining above this is called No. 1 Buckwheat. The next screen has holes ⅛ in. in diameter, which holds the No. 2, and a third screen has holes 3/32 in. in diameter, and the coal remaining upon it is No. 3 Buckwheat. Below this screen is a pan to collect the dust.

Coal is delivered to the plant in cars and from these by means of a skip hoist and Robbins belt conveyor it goes to the bunkers over the boilers, which have a capacity of about 4000 tons. From these, chutes lead to the floor of the boiler room just in front of the boilers, and the coal is shoveled by hand from this floor to the furnaces.

Method of Firing

There are 3 fire doors to each furnace, making 6 to each boiler, and the method of firing employed is to cover the entire grate surface with a thin layer of coal each time the fire is replenished, which is done just after the coal has reached the incandescent state. As soon as the coal has become ignited a light rake is used to level the bed and cover up holes which have formed. When the bed of ashes coals has reached 8 to 9 in. in thickness, the ashes are dumped, which occurs about twice in 24 hr. The cleaning period is so arranged that only one fire is cleaned at a time.

An air pressure of 3 to 4 in. is carried under the grates, being furnished by a Sirocco blower and supplemented by Argand blowers on the end boilers. The following is a list of the loss in draft from the ashpit to the stack which has been found to give best results on the test boiler. A photograph herewith shows the arrangement of the draft gages on a board, which are used during test periods. Draft loss between ashpit and fire 1.76 in., between furnace and top of first pass 0.005; from top of first pass to bottom of second pass 0.348; from bottom of second pass to top of third pass 0.21; top of third pass to bottom of economizer 0.31; bottom of economizer to stack 0.007.

The amount of coal burned per square foot during the test of the plant averaged about 35 lb. This was made under operating conditions and represents fairly well the average rate of combustion.

Coal is weighed as it is delivered to the bunkers over the boilers, and on the 1st and 16th of each month an estimate is made of the amount remaining in the bunkers. The semi-yearly test is run to determine the economy secured and to see whether any losses have crept in unnoticed by the operators. The results of a representative test are given herewith:

Total fuel	488,927 lb.
Fuel for electric load	406,526 lb.
Total water	3,527,871 lb.
Total water for electric load	2,927,084 lb.
Lb. of water per lb. coal	7.22
Total Kw.-hr. generated	151,200
Kw.-hr. delivered to the R. R.	140,701
Lb. coal per kw.-hr.	2.84
Lb. of coal per kw.-hr. for R. R.	3.13
Lb. of coal per kw.-hr. used for auxiliary	0.30
Lb. of steam per kw.-hr. of total current	20.69
Lb. of steam per kw.-hr. for R. R. load	22.89
Lb. of steam per kw.-hr. used for auxiliaries	2.19
Average temperature with one feed water heater out of service	142 deg
Average temperature of water delivered to boiler	200 deg.
Average temperature of steam to turbines	474 deg
Average steam pressure at boilers	184 lb.
Average pressure at the turbines	177 lb.

The load factor was determined by dividing the average load by the maximum power load and resulted in 46 per cent. The average load upon the plant from 2 a. m. to 4 a. m. was 2000 kw. At 9 a. m. the load was 15,000 kw., at noon 5600 kw., and at 6 p. m. 13,200 kw.

Caustic Soda and Boiler Corrosion

EXPERIMENTS SHOW THAT EXCESS SODA MAY CAUSE CORROSION, PITTING AND LAP CRACKS WITH POSSIBILITY OF RESULTING EXPLOSION. BY F. F. VATER

A PAPER communicated to the Transactions of the Faraday Society, December, 1913, by J. H. Andrew, entitled, "The Embrittling of Iron by Caustic Soda," is not only very interesting, but describes some research work as to the effect of caustic soda on iron and steel, which everyone connected with the boiler end of power plant operation should know.

It is the purpose of this article to outline briefly some of the determinations made by Mr. Andrew, and to cite several instances where boiler troubles have occurred, which were very likely caused directly by caustic soda in the feed water.

Mr. Andrew's attention, as he expresses it, "was drawn to the peculiar, although not uncommon occurrence of extreme brittleness in an iron tube which had been in use in a caustic soda concentrator. The tube was one of many which had broken off during the repairing of the concentrator, the breaking taking place at the expanded ends of the tubes."

The metal of the tube ends had changed from a fibrous to a crystalline structure.

He refers to Mr. Stromeyer's experience in allowing a caustic soda liquor to concentrate beyond 100 deg. Twaddell (specific gravity 1.5) resulting in the mild steel becoming brittle, the plates to crack and rivet heads to fly off. Mr. Stromeyer suggested "the possibility that in the presence of caustic soda and iron, water splits up, the oxygen forming ferric oxide or acid which combines with the caustic, while the hydrogen is occluded by the iron metal. This would account for the extraordinary brittleness which is imparted to mild steel or iron vessels in which caustic soda liquor is being concentrated, more particularly as this brittleness makes its appearance chiefly if not exclusively in closed vessels to which air is not admitted, and where corrosion, if at all active, is very slight."

Mr. Andrew states: "Roberts-Austin has shown that when iron is made the negative electrode in a battery decomposing acidulated water, a part of the hydrogen formed at the cathode is occluded by the iron, the metal after this treatment giving the well known hydrogen points in a cooling curve determination."

Also: "Sieverts has shown that iron begins to occlude hydrogen at a temperature of about 400 deg. C. (752 deg. F.). It must be remembered that his experiments were carried on with molecular hydrogen, atomic hydrogen, as Roberts-Austin has shown being occluded by iron at ordinary temperatures, and it is in this state that hydrogen must exist previous to its evolution as molecular hydrogen, from the metallic surface in caustic soda experiments."

Mr. Andrew conducted a series of experiments on wrought iron and steel submerged in caustic soda solutions and determined definitely:

That iron occluded hydrogen at a temperature of 100 deg. C. equal to 212 deg. F.

That the occlusion of hydrogen changed the structure of the metal from fibrous to crystalline throughout the mass.

That by driving off the hydrogen with heat the metal assumed again its fibrous form.

That where the caustic soda solution was exposed to the air, decomposition or corrosion of the metal set in promptly, but decreased in severity the longer it was submerged, due, no doubt, to the decomposition of electric iron on the surfaces of the metal.

That the decomposition or corrosion is electrolytic, due to a difference in potential between the amorphous and crystalline phases.

That iron under tension occluded hydrogen while iron normal or under compression did not.

These are the conclusions reached and one cannot but be impressed in reading the article with the care exercised in making the determinations, and therefore, with the accuracy of the conclusions reached.

In the middle west, quite a little trouble has been experienced with steam boilers. These troubles consist of cracks in the plates, ruptured seams, ruptured plates and serious explosions.

Wherever the cracks were found, they were generally short, seldom exceeding 1 in. in length, unless they extended from rivet hole to rivet hole. They never extended into the body of the plate beyond the lap of the other plate, but often extended from the rivet hole to the edge of the plate at the seam. Sometimes there are 2 parallel cracks, one extending from hole to hole, and one only part of the distance.

Invariably, examinations of the cracked metal showed its structure had been changed from fibrous to crystalline.

The troubles did not occur in any one type or make of boiler, horizontal fire tube, internally fired and water-tube boilers meeting the same fate, nor did the trouble occur in one special part of the boiler. In the fact that the cracks and subsequent ruptures were *all below the water line* in the boiler, the conditions were alike.

Sections of plates away from the cracks or tears, upon test showed metal that was properly used in constructing a steam boiler.

The number of cases which have come to my notice of troubles of this kind is 22, and there are doubtless many more.

Another condition uniform in nearly all of the plants where trouble has been experienced is that artesian well water was used for boiler feed. The cases are all in distinct geographical districts and in districts where sodium bicarbonate is present in many artesian well waters. In 4 of the cases, analyses of the feed water shows the presence of sodium bicarbonate in quantity from 7 to 9 grains per U. S. gallon.

Sodium bicarbonate at low temperatures is a stable salt, but at temperatures met in boiler practice, it is known to separate, giving off its carbonic acid and thus becoming caustic soda or sodium hydrate. There is then in the water, where the trouble occurs, the same substance which Mr. Andrews has shown does cause the very trouble they have experienced at the 22 plants referred to.

Were it not for the fact that in the experiments conducted by Mr. Andrew, all were made with saturated solutions of caustic soda, while under the worst condition, it would be impossible to obtain even approximately a saturated solution in the boiler with the quantity of soda, shown by analysis, there would seem to be little room for argument as to the cause of the trouble.

In Mr. Andrew's tests no considerable length of time elapsed between the immersion of the samples in the caustic soda solutions and the completion of the tests. It was a question of days only. It is unquestionably true that saturated solutions would bring about the crystalline structure in the metal much more quickly than a dilute solution, and in some of the cases where troubles with boilers occurred, they had been in service 4 or 5 yr. before its culmination; therefore, the dilute solutions would have had time to bring about the same condition that existed in a short length of time where saturated solutions were used in the tests.

Were the troubles experienced in any particular line of power plant service, which might have contributed to the trouble, there would be reason to believe caustic soda was not necessarily the cause.

But the troubles occurred in power plants serving different industries, such as electric railway and lighting, brick yards, flour mills, heating plants and other manufacturing plants. In chemical plants producing caustic soda and under conditions where it could readily contaminate the boiler feed water through leakage, parallel troubles have existed.

On the other hand, I know of one plant in Central Illinois where artesian well water is used containing not to exceed 4.75 grains per gallon of sodium bicarbonate, where they have had no trouble of this kind. Again in the Southwest, a plant has operated 10 yr. without experiencing any trouble from cracked plates or ruptures, although the artesian well water they use contains as high as 15 grains per gallon of sodium bicarbonate, and there are doubtless other cases which have not come to my attention.

As far as my knowledge extends, there are 22 plants with trouble as against 2 without trouble.

It would be interesting to know in either case what saturations were permitted in the boilers. It seems to me probable that caustic soda is the cause or, in any event, it is possibly the cause. If there be doubt in the mind of anyone, it can at least do no harm to protect against such a condition arising in his own plants by being careful in the use of caustic soda or soda ash, either as a boiler compound or as a reagent in a water softening equipment.

I have seen a plant where the excess soda ash used in the treatment of water amounted to 14 grains per gallon. This would show in a titration report on the treated water as causticity, 7. It might be reported as alkalinity to phenol. This plant is now out of commission, and it did not operate long enough to parallel the time, where cracks and ruptures occurred.

Any water treating plant can be made to show a low hardness by carrying a high causticity, but it is costing money in the increased cost of treatment and, in addition, is creating the possibility of trouble, due to the occlusion of hydrogen. Water softening equipments are in the service where the hardness of a water is reduced to 1½ grains per gallon with a causticity or alkalinity to phenol of 0.5. There certainly would be small chance of permitting saturations that would be likely to cause trouble at this low causticity. In one particular instance, such a plant has been in operation more than 6 years without any trouble whatever.

If caustic soda is the cause of cracked plates, tears and ruptures in boilers, as it probably is, it will pay well to watch closely its use. If it is not directly the cause, it will be well to be cautious in its use until it is proven beyond doubt that in weak solutions it does or does not crystallize the metal in boilers.

Watch the causticity in your softening system titrations and if you are using the substance as a boiler compound, check the quantity you use with a titrating set, which should be a part of the equipment of every boiler room.

When a plant is so situated as to be compelled to use an artesian well water, containing sodium bicarbonate, the use of a strong oxidizing agent, such as the bichromate of potash, will prevent the trouble from occurring. The hydrogen liberated when the water breaks up into its original elements will be absorbed by the oxygen, given up by the bichromate, forming water again and leaving no hydrogen to be occluded by the metal.

It can also be used to prevent pitting or corrosion in water tanks or pipe lines, as I have used it successfully to prevent the internal corrosion of underground mains in central station heating plants, circulating hot water.

Its use for this purpose according to Cushman is to increase the osmotic pressure of water beyond the equilibrium due to tension pressure in the steel.

MEMBERSHIP IN the National Gas Engine Association is growing rapidly; among the new members recently joining are the Alamo Mfg. Co., Hillsdale, Mich.; Charter Gas Engine Co., Sterling, Ill.; J. I. Case T. M. Co., Racine, Wis.; Emerson-Brantingham Implement Co., Rockford, Ill.; Moline Plow Co., Moline, Ill.

At the meeting of the Standardization Committee recently held in Chicago, the standard belt speed of 1500 ft. a minute was considered too low, and the committee decided to recommend, in its report of next June, a belt speed of not less than 2000 ft., with the use of larger pulleys than are now common on engines, in order to reduce the slip.

In view of the fact that most engines are sold for use above sea level, and within a range of 1000 ft., the proposed standard gas engine guarantee was modified to cover the developing of the rated horsepower at rated speed, at altitudes not exceeding 1000 ft. above sea level, with a consumption of a definite amount of a definite fuel having specific gravity as specified. This guarantee will come up for further discussion by the committee.

The committee also approved a number of standards of the Automobile Engineers, for over-sized cylinders, carburetor fittings and flanges, cotter pin sizes, screw stock and iron castings, and the Automobile Engineers' magneto dimensions for high tension magnetos were approved.

Other standards under consideration are the bolt circles for clutch pulleys, sizes for gas engine pulleys, and the standardization of the names for parts of engines. Data sheets are now being sent out by Secretary Brate on pumps and allied topics.

Steam Chart

SIMPLE AND ACCURATE MEANS FOR SOLVING STEAM AND WATER PIPING PROBLEMS. BY P. M. GALLO

POWER house arrangements and rearrangements embody a certain amount of tedious calculations, such as boiler capacity, pipe sizes for steam and condenser water piping. These calculations wholly or partly must be repeated at every rearrangement. This consumes more or less time, as it must be done with sufficient accuracy to avoid any serious mistake in size of equipment required. The accompanying steam chart will greatly reduce the time required for these calculations and reduce the liability of error to a minimum.

The aim in laying out this chart was to get the maximum information with the greatest simplicity on a minimum size sheet, yet to get results within the practical limits of accuracy. Too many different curves or too many lines to a given curve, or both, or a number of curves bunched and crossing each other has been avoided as much as possible, for this only complicates the chart's manipulation and increases the liability of error, unless a person uses them continually; in other words, they are worse than no charts at all to the casual user.

This chart is primarily designed for steam, and secondarily for water flow in pipes, as this is an important item in condensing steam power plants.

As I accept with reserve any formula, table or chart not having its derivation or basis of calculation explicitly stated, having been misguided once by such a table, and to prevent readers from accepting this chart similarly, I feel it my duty to state fully its basis of calculation. Its construction is self-evident.

In laying out a power house, the first consideration is the amount, nature and variety of power required. From this and the desired flexibility, size and shape of ground, area available, consideration of future expansion, capital at hand, etc., the kind, number and size of units are determined. From the kind and size and output per given unit, the steam pressure is decided. From the kind of unit, radiation losses and distance between boiler and engine room, the degree of superheat is decided.

From the manufacturer of these units, the steam consumption is obtained for various loads. As the steam consumption so obtained is usually that under the most favorable conditions of operation, it should be checked with data obtained from users of similar machines, if available, otherwise it would be safer to add 10 per cent to the given rate of steam consumption.

This steam consumption is always given in pounds per hour per brake horsepower or per kilowatt-hour output. Since this is the first rational quantity arrived at in power plant design, it is used as the basis from which the accompanying steam chart is calculated and constructed. To make the readings more accurate, pounds of steam per minute are used.

Gage pressure lines represent the pressure at the throttle or at the point of application.

Pounds of steam per minute is the steam consumed at the point or points of application, either saturated dry or at a given degree of superheat.

The cubic feet scale shows the volume of the dry saturated or the superheated steam, at the point or points of application.

The superheat lines are based on the average increased volume of steam for a given degree of superheat covering the average range of pressure.

The actual and nominal pipe diameter scales are self explanatory.

Velocity curves are self explanatory.

The boiler horsepower scale is based on 34½ lb. of water evaporated per hour from and at 212 deg. F., into steam at zero gage pressure or 14.7 lb. absolute equals one boiler horsepower.

Since the superheating surface is always independent of the evaporating surface and has absolutely no effect on the rate of evaporation, the boiler horsepower is always referred to the saturated steam line on the chart.

The feed water correction scale give a factor at any degree F. temperature of feed water, by which the boiler horsepower found from chart must be multiplied to obtain the actual boiler horsepower required.

Marks & Davis steam tables were used in computing this chart.

To use the chart for the flow of water in pipes a second row of figures are placed on the velocity curves. These figures are obtained by dividing the steam velocities by 10 and then by 60 to reduce the reading to feet per second, thus avoiding the possibility of reading the wrong figure when using chart for either steam or water.

The chart is composed of 2 scales, the upper scale marked A and the lower scale marked B.

The lower scales, B, B1 and B3, are 1/10 the upper scales marked respectively A, A1 and A3. Scale B2 is scale A2 divided by the square root of ten, or A2 $\div \sqrt{10}$.

For steam, all scales marked by the same prefix letter work together and should be so used, that is, all scales marked A and all scales marked B should be used together.

The limits of the scales may be extended both ways by multiplying or by dividing either scale A or B by 100. Multiplying any one of the scales A, A1, A3, or B, B1, B3, by 100, multiplies the other two by 100, and scales A2 and B2 by 10. Similarly, dividing any one of the scales A, A1, A3, or B, B1, B3, by 100, also divides the remaining two by 100, and scales A2 and B2 by 10. This division will often be needed when dealing with problems of water flow. As the 2 scales A and B are overlapping the range of the chart is unlimited.

As the scales stand the range is from 100 to 11,000 boiler horsepower. Dividing scales B by 100, and multiplying scales A by 100, increases the range from 1 to 1,100,000 boiler horsepower.

For water calculations the scales must be crossed to make chart direct reading, that is, use A1 with B2 $\times$ 10 and B1 with A2.

As few lines as possible have been used in the construction of this chart to facilitate manipulation, intermediate values being obtained by interpolation, which is a

simple operation, as the value of any intermediate point is directly proportional to its relative distance from the adjacent curves or lines.

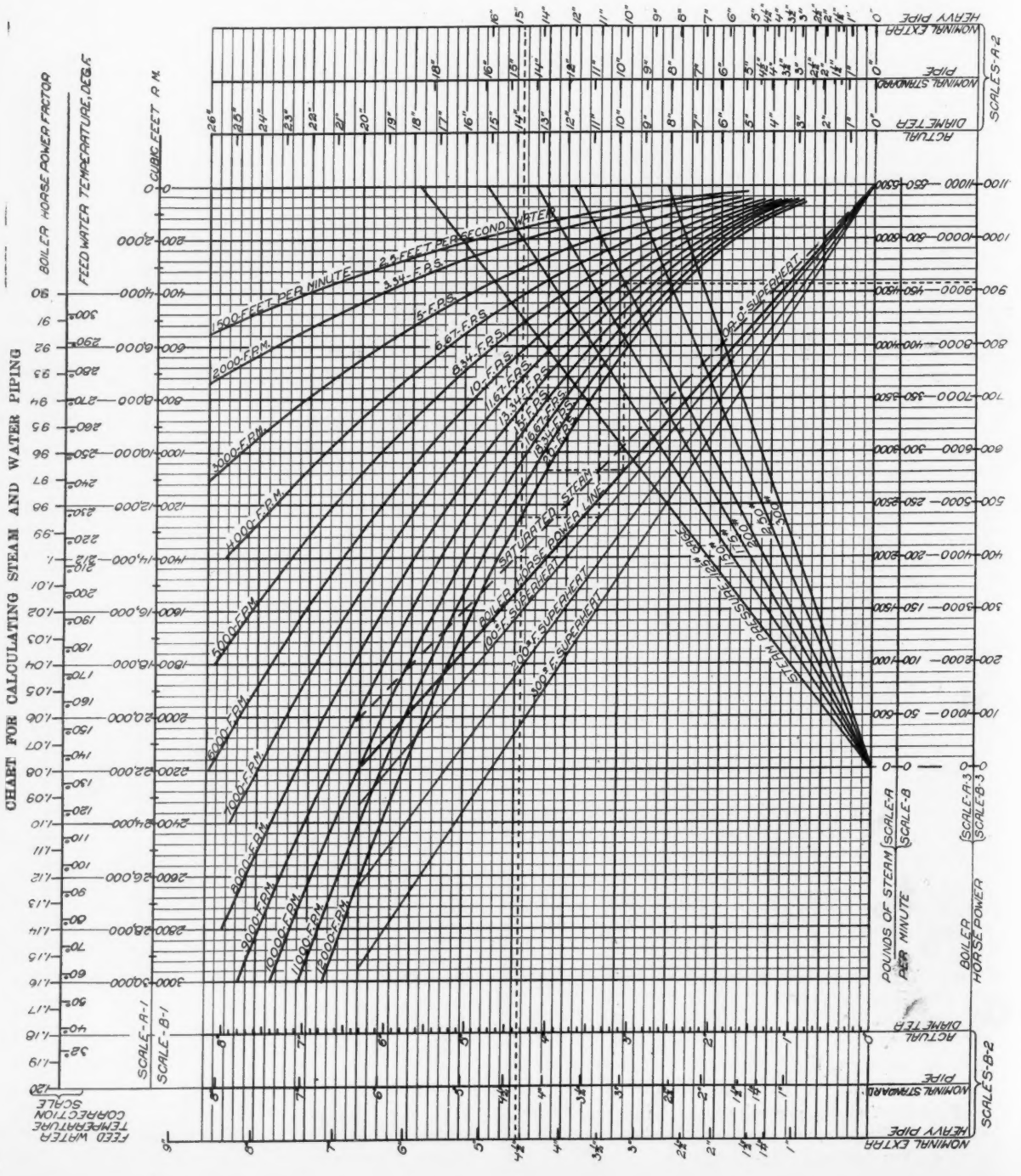
Interpolation between the velocity curves and the superheat lines must be based on the horizontal distance between adjacent curves or lines. Ex.: the velocity, 6500 f.p.m., lies half way horizontally between the 6000 and 7000 f.p.m. curves; 6250 f.p.m. lies one-fourth the distance between adjacent curves.

Similarly, 250 deg. superheat is half way between the 200 and 300 deg. lines horizontally; 50 deg. lies halfway horizontally between the 0 or saturated steam line and the 100 deg. line. 220 deg. and 20 deg. lie respectively one-fifth this distance, between adjacent lines.

On the back of the chart are enumerated some of the computations that can be performed with this chart:

FOR STEAM

1. Given: Pounds saturated steam per minute and pressure.
   Find: Volume, cubic feet per minute.
   Solution: From scale A or B, vertically up to gage pressure line, horizontally to saturated steam line, vertically to scales A1 or B1 and read cubic feet per minute.
2. Given: Pounds steam per minute, degree of superheat and pressure.



Find: Volume cubic feet per minute.
Solution: From scale A or B, vertically up to pressure line, horizontally to degree of superheat line, vertically to scales A1 or B1, and read cubic feet per minute.

3. Given: Pounds steam per minute, pressure and velocity.
Find: Pipe diameter.
Solution: From scales A or B, vertically up to pressure line, horizontally to saturated steam line, vertically to velocity curve, horizontally to right for scale A, or to left for scale B, and read pipe diameter in inches on scales A2 or B2.

4. Given: Pounds steam per minute, degrees superheat, pressure and velocity.
Find: Pipe diameter.
Solution: From scales A or B, vertically up to pressure line, horizontally to degree of superheat line, vertically to velocity curve, horizontally to scales A2 or B2, and read diameter of pipe inches.

5. Given: Cubic feet per minute and velocity.
Find: Pipe diameter.
Solution: From scales A1 or B1 vertically down to velocity curve, horizontally to scales A2 or B2 and read pipe diameter.

6. Given: Pounds steam per minute and pressure.
Find: Boiler horsepower for feed water, 212 deg.
Solution: From scale A or B, vertically up to pressure line, horizontally to saturated steam line, vertically to b.hp. diagonal, horizontally to same pressure line, vertically down to scale A3 or B3 and read boiler horsepower.

7. Given: Pounds steam per minute, feed water temperature and pressure.
Find: Boiler horsepower.
Solution: Proceed same as in case 6, and multiply b.hp. so obtained by factor opposite degrees feed water temperature in feed water temperature correction scale. Result is b. hp. required.

8. Given: Cubic feet saturated steam per minute, and pressure.
Find: Boiler horsepower.
Solution: From scales A1 or B1 vertically down to b.hp. diagonal horizontally to pressure line, vertically down to scales A3 or B3 and read boiler horsepower for feed water at 212 deg.

9. Given: Cubic feet steam per minute, degree of superheat, and pressure.
Find: Boiler horsepower.
Solution: From scales A1 or B1 vertically down to degree of superheat line, horizontally to saturated steam line, vertically to b.hp. diagonal, horizontally to pressure line, vertically down to scales A3 or B3 and read b.hp. for feed water at 212 deg.

10. Given: Cubic feet steam per minute and degree of superheat.
Find: Cubic feet steam per minute saturated.
Solution: From scales A1 or B1 vertically down to degree of superheat line, horizontally to saturated steam line, vertically up to scales A1 or B1, and read cubic feet per minute saturated steam.

11. Given: Cubic feet steam saturated.
Find: Cubic feet steam superheated a given degree.
Solution: Reverse the operation of Ex. 10.

12. Given: Cubic feet saturated steam and pressure.
Find: Pounds steam per minute.
Solution: From scales A1 or B1 vertically down to saturated steam line, horizontally to pressure line, vertically down to scales A or B and read pounds per minute.

13. Given: Cubic feet per minute superheated steam and pressure.
Find: Pounds steam per minute.
Solution: From scales A1 or B1 vertically down to degree of superheat line, horizontally to pressure line, vertically to scales A or B and read pounds steam per minute.

14. Given: Pounds saturated steam per minute, pipe diameter and pressure.
Find: Velocity.
Solution: From scales A or B vertically up to pressure line, horizontally to saturated steam line, vertically to a horizontal line through pipe diameter, this point of intersection gives the velocity. If this point of intersection falls between 2 velocity curves, its velocity is directly proportional to its horizontal position between these curves, i. e., if it falls ¼ the horizontal distance between the 8000 and 9000 f.p.m. curves, the velocity would be 8250 f.p.m.; if 2/5, it would be 8400 f.p.m.

15. Given: Pounds steam per minute, degree of superheat, pipe diameter, and pressure.
Find: Velocity.
Solution: From scales A or B, vertically down to pressure line, horizontally to degree of superheat line, vertically to horizontal line through pipe diameter; intersection gives the velocity same as in Case 14.

16. Given: Pressure and boiler horsepower.
Find: Pounds steam per minute.
Solution: From scales A3 or B3 vertically up to pressure line, horizontally to b.hp. diagonal, vertically up to saturated steam line, horizontally to same pressure line, vertically up to scales A or B, and read pounds steam per minute.

17. Given: Boiler horsepower pressure and velocity.
Find: Pipe diameter.
Solution: From scales A3 or B3 vertically up to pressure line horizontally to boiler horsepower diagonally, vertically to velocity curve, horizontally to scales A2 or B2 and read off pipe diameter.

18. Given: Boiler horsepower, pressure, velocity, degree of superheat.
Find: Pipe diameter.
Solution: From scales A3 or B3 vertically up to pressure line, horizontally to b.hp. diagonal, vertically up to saturated steam line, horizontally to degree of superheat, vertically to velocity curve, horizontally to scales A2 or B2 and read pipe diameter.

19. Given: Boiler horsepower, feed water temperature, pressure.
Find: Pounds steam per minute.
Solution: Divide given boiler horsepower by factor opposite feed water temperature in feed water temperature correction scale, result is boiler horsepower from feed water at 212 deg. F., then proceed as in Case 16.

20. Given: Pipe diameter, velocity, pressure.
Find: Boiler horsepower.
Solution: From scales A2 or B2 horizontally to velocity curve, vertically to boiler horsepower diagonal, horizontally to pressure line, vertically down to scales A3 or B3 and read boiler horsepower.

21. Volume of a vessel cubic feet, full of steam at a given pressure, saturated or superheated.
Find: Weight of steam it holds in pounds.
Solution: From scales A1 or B1, vertically down to saturated or superheat line, horizontally to pressure line, vertically down to scales A or B and read pounds steam contained in vessel.

For Water Flow in Pipes

22. Given: Cubic feet water per minute, velocity feet per second.
Find: Pipe diameter.
Solution: From scale B1, vertically down to velocity curve f.p.s., horizontally to scale A2 and read pipe diameter.
Or, From scale A1 vertically down to velocity curve f.p.s., horizontally to scale B2, read pipe diameter and multiply it by 10.

23. Given: Cubic feet water per minute, pipe diameter.
Find: Velocity feet per second.
Solution: From scale A2 pipe diameter, horizontally to vertical through cubic feet per minute scale B1, intersection gives velocity feet per second.
Or, Divide pipe diameter by 10, from this figure on scale B2 horizontally to vertical through cu.ft.p.m. scale A1, intersection gives velocity feet per second.

24. Given: Velocity feet per second, pipe diameter.
Find: Cubic feet per minute.
Solution: From scale A2 horizontally to velocity curve f.p.s., vertically to scale B1, and real cubic feet per minute.
Or, Divide pipe diameter by 10, from this figure on scale B2 horizontally to velocity curve f.p.s., vertically to scale A1, and read cubic feet per minute.

Note: The abbreviations used in these examples are: b.hp. = boiler horsepower, f.p.m. = feet per minute, cu. f.p.m. = cubic feet per minute, f.p.s. = feet per second.

As water is often rated in gallons per minute to convert to cu. f.p.m., divide by 7.48, or to convert cu f.p.m. into gallons per minute, multiply by 7.48; in practice this factor is usually taken as 7.5 to simplify calculations.

The letter F. following degrees of heat, means degrees Fahrenheit.

The degrees of superheat generally and as used here means the degrees of temperature above the temperature of saturated steam at the given pressure.

As the water velocity figures, on curves, are obtained by dividing the steam velocities by 10 and by 60 to reduce to seconds, the water velocities will be in ⅓ foot fractions in most cases. Remembering that the intermediate velocities lie horizontally proportionate between adjacent curves as previously stated for steam, it is not so serious to locate the next even velocity figure. For example, let the velocity of 8 f.p.s. be desired. The adjacent velocities noted are 8.34 or 8⅓ f.p.s., and 6.67 or 6⅔ f.p.s. The difference is 5/3 f.p.s., and 8 f.p.s. is ⅓ f.p.s. from the 8.34 f.p.s. curve. Therefore it is 1/5 the horizontal distance between these curves from the 8.34 f.p.s. curve.

For direct reading, use scale B1, velocity curves f.p.s. and scale A2 together.

For scale A1, velocity curves f.p.s. and scale B2, multiply scale B2 by 10. That is what now reads 6 in. diameter pipe would be read as 60 in. diameter pipe. By dividing the velocity f.p.s. by 10, use scale A1, velocity curves f.p.s. ÷ 10 and scale A2 multiplied by 10. That is what reads 5 f.p.s. on velocity curves would read 0.5 f.p.s., and what reads 14 in. diameter pipe on scale A2 would be read 140 in. diameter.

The range of velocities for water is therefore from ¼ to 20 f.p.s., and the volume from 0 up to 30,000 cu. f.p.m.

Remarks

Many of the solutions given for the examples seem difficult, but are in reality simple; all that is necessary is to understand the construction and arrangement of the chart.

The criticism may and will be made that this chart does not consider friction and radiation losses. If this were also plotted on the chart it would complicate it so as to make it impractical. The values plotted consider the piping system as having no friction and no radiation losses, and all values are concrete terms that can be measured and can be obtained in practice very closely. Friction and radiation losses are indeterminate and fluctuating quantities, the exact laws of which are not yet fully established. The function of this chart is to proportion the piping, boilers, etc., not considering friction and radiation. Then when a satisfactory layout has been obtained, calculate the friction and radiation losses and it is an easy matter to alter the various pipe sizes to suit. As the friction and radiation loss is a function of the pressure it can easily be taken care of by raising the boiler pressure 1 or 2 lb., which would not perceptibly increase the boiler capacity, as it is in any case proportioned for a certain percentage excess capacity. In well laid out power plants the friction and radiation loss for steam seldom exceed 1 to 2 lb. per square inch pressure drop.

Superheating the steam of a given boiler does not increase its evaporative power, therefore it does not increase the boiler horsepower; in fact, it affects it neither way, but it does increase slightly the coal consumption of that boiler per boiler horsepower.

Superheating the steam increases the brake horsepower output of an engine or turbine, consequently less pounds of steam are required per unit output and the boiler horsepower may be correspondingly reduced.

The gage pressure range covers the general modern practice, but if anybody desires a pressure line not given, find the cubic feet for 550 lb. of steam at that pressure, then from this figure on scale B1 vertically to saturated steam line, horizontally to vertical through 550 lb. on scale B. Point of intersection is a point on the pressure line. Through this point and the common point of intersection of the pressure lines draw a straight line, which will be the pressure line required.

Solution of a practical example plotted on chart in dotted lines follows:

Required: 5000 lb. saturated steam per minute at 200 lb. gage pressure.

Find: Boiler horsepower.

Solution: From 5000 on scale A vertically to the 200 lb. pressure line, horizontally to saturated steam line, vertically to boiler horsepower line, horizontally to 200 lb. pressure line, vertically to scale A3 and read 9150 b.hp.

For 500 lb. steam per minute the same lines are followed and read off on scale B3 915 b.hp.

Find: Pipe diameter at 12,000 f.p.m. velocity.

Solution: From 5000 on scale A vertically to 200 lb. pressure line, horizontally to saturated steam line, vertically to 12,000 f.p.m. curve, horizontally to scale A2 and read 12.75 in., actual pipe diameter or 14 in. as nearest standard or extra heavy nominal pipe.

For 500 lb. steam per minute, pass from same intersection on 12,000 f.p.m. velocity curve to scale B2 and read 4.03 in., actual pipe diameter, or 4 in. nearest nominal standard pipe, or 4½ in. nearest nominal extra heavy pipe.

Find: Cubic feet per minute.

Solution: From 5000 on scale A vertically to 200 lb. pressure line, horizontally to saturated steam line, vertically to scale A1 and read 10,700 cu.f.p.m.

For 500 lb. steam per minute follow same lines but read off on scale B1 or 1070 cu.f.p.m.

Find: Pipe diameter at 100 deg. F. superheat.

Solution: From 5000 on scale A vertically to 200 lb. pressure line, horizontally to 100 deg. superheat line, vertically to 12,000 f.p.m. curve, horizontally to scale A2 and read 13.75 in., actual pipe diameter, or 15 in. as nearest nominal standard or extra heavy pipe.

For 500 lb. steam per minute, follow same lines but from 12,000 f.p.m. curve pass horizontally to scale B2 and read 4.35 in., actual diameter, or 4½ in. as nearest nominal standard or extra heavy pipe.

Find: Cubic feet per minute at 100 deg. F. superheat.

Solution: Follow lines as in previous example to 100 deg. superheat line, then vertically to scales A1 and B1, and read respectively 12,460 and 1246 cu.f.p.m. for 5000 and 500 lb. steam per minute.

Costs of ice making as given in discussion at the meeting of the N. A. of P. R. E., were as follows: For a 25-ton raw water ice plant, with condensing water at 86 deg. and electricity at 7.5 mills per kw.-hr., 40 kw.-hr. were required per ton of ice, or 30 cents a ton, cost of power. Other figures given were 44 to 64 cents a ton. Using gas as fuel, heat value 945 B.t.u. per cu. ft. and 3200 cu. ft. used per ton of ice, with condenser water at 63 deg., the power cost was 32 cents per ton of ice made. Using coal, the power cost was given at from 34 to 60 cents.

Electrical Machinery and Appliances

For Generating, Transmitting and Using Current

The Thury System

DESCRIPTION OF HIGH-TENSION DIRECT-CURRENT TRANSMISSION SYSTEM; ITS ADVANTAGES AND DISADVANTAGES; GENERATORS AND MOTORS. BY W. BAUM

IN the usual transmission system, one or several generators connected in parallel feed the line at a constant potential, the current being allowed to vary with the load. In the Thury system of direct-current transmission the generators supplying the power and the motors absorbing it are all connected in series; the voltage varies with the load while current is kept constant. As the current is constant and exactly the same in the whole of the circuit, the line and machine losses due to ohmic resistance are, therefore, also constant and independent of the load. Figure 1 is a simple representation of the Thury system with generator and motor connections. Figure 2 shows the short-circuiting switch by means of which the generators and motors can be switched in or out of circuit and disconnected from the line.

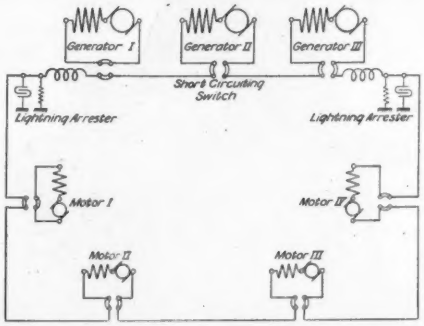


FIG. 1. DIAGRAM OF A SERIES CIRCUIT FOR THE GENERATION, TRANSMISSION AND UTILIZATION OF HIGH-TENSION DIRECT CURRENT

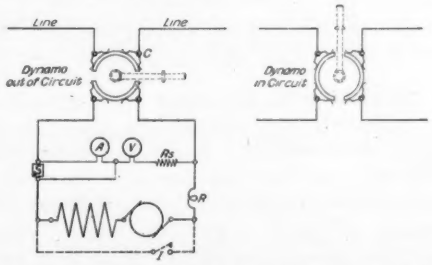


FIG. 2. DIAGRAM OF SHORT-CIRCUITING SWITCH EMPLOYED IN THE SERIES CIRCUIT SHOWN IN FIG. 1

The maximum power obtainable in this system is determined on one hand by the strength of the constant current, which may range from 50 to 450 amp., and on the other hand, for a given current by the maximum permissible voltage.

The Thury system permits the transmission of power from the generators directly to the motors without the aid of any intermediary such as transformers, and at the same time leaves the generators and motors as independent units. Figure 3 gives examples of a Thury series system showing the closed-ring principle without any switch, apparatus or machine capable of breaking the circuit.

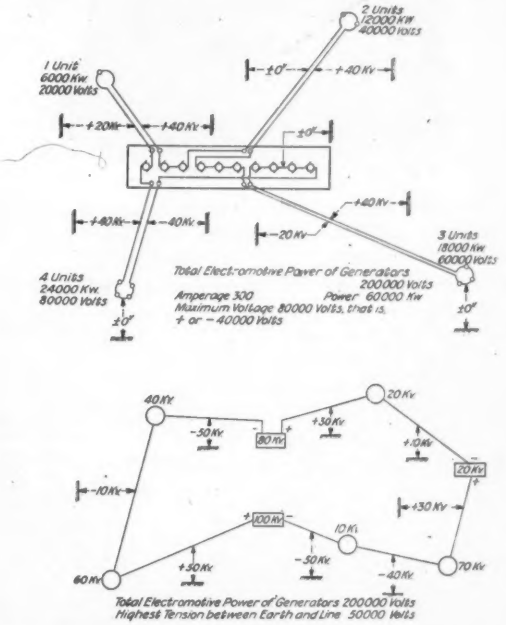


FIG. 3. TYPICAL EXAMPLES OF SERIES CIRCUITS WITH KILOWATT AND KILOVOLT DATA

Among the chief practical advantages of the direct-current series system are, the use of high-tension underground cables in which losses in the dielectrics are practically eliminated, the higher voltage which can be used, the great simplicity of the central stations on account of the absence of step-up and step-down transformers, the absence of complicated switch gear such as circuit breakers and the usual breaking switches, and the impossibility of an excessive flow of current in case of damage to machines.

This system of transmission allows the use of any natural source of power, great or small, which happens to exist in the regions through which the lines run. Individual central stations connected in series are entirely independent of local overloads or lack of demand, whatever the relative importance of these stations may be or whether the distance is great or small from the points of consumption.

When the series system is combined with alternating-current distribution plants, there is no difficulty in linking together several lines fed by alternating stations of different frequency. Series motor-generators thus acting as a link form an elastic coupling for correcting both the variations of load, and the differences of voltage caused by the load on the lines.

Exceedingly high tension can be obtained with direct current by connecting in series several units at reduced voltage without any machine having to stand more than 5000 v. between frame and winding. This subdivision

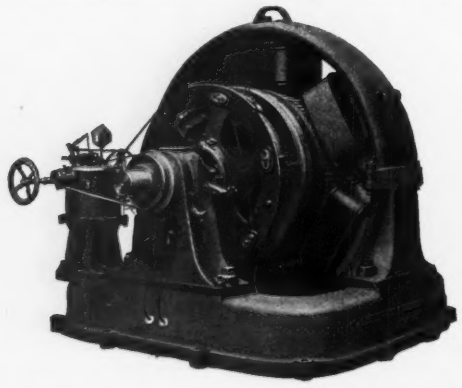


FIG. 4. DIRECT-CURRENT SERIES SYSTEM GENERATOR OF 170 KW., 375 R.P.M., 3400 V., 50 AMP.

of the tension has not only the advantage that intermediate transformers are unnecessary, but greater safety in working and simplicity of installation is effected.

The Thury direct-current system permits the practical use of the earth as an active conductor, resulting in a reduction of 75 per cent in the necessary weight of copper for the same tension.

The resistance of the earth terminals, if they are well established, ought not to exceed 1 ohm. This resistance is only local, the distance separating the 2 terminals being of no influence. The earth can be used in 2 ways, as a neutral or as an active conductor. As a neutral it transmits no current, but only limits the difference of tension between the extreme conductors and the earth to half the total tension. In case of an accident on one of the lines, it permits the other to transmit at least ½ the energy.

EQUIPMENT

WHEREAS alternating current can be transformed by static transformers, the transformation of direct current requires rotative machines which are more expensive, require greater up-keep and are less efficient. This and the impossibility of subdividing the constant current are the 2 principal reasons which limit the use of direct-current series transmission.

With alternating current, however, the transformer must take the full voltage and therefore requires elaborate protecting apparatus, whereas the machines of the direct-current series system only take a part of the total tension. For instance, a motor of 1000 hp. in series on a circuit of 300 amp. and 100,000 v. is designed for but 3000 v. A motor for an output of 100 hp. and fed by the same circuit would be designed for 300 v.

Where the Thury system is used, no general switchboards are required. The necessary instruments are fitted on the machines and are, therefore, insulated by the machine insulation. Only a panel with the controlling instruments is installed at some distance from the machines and if an earth return is not used the panel must be insulated from the ground. This panel may carry a wattmeter, a voltmeter, a standard ammeter, and, if necessary, a registering voltmeter; these instruments being at the same voltage, can be manipulated when working without any danger.

In this system, the commutators are a weak point, as they must be carefully made and generously proportioned, an item which considerably augments the cost of the machines. Attention must also be paid to the commutators during operation, in which respect alternating-

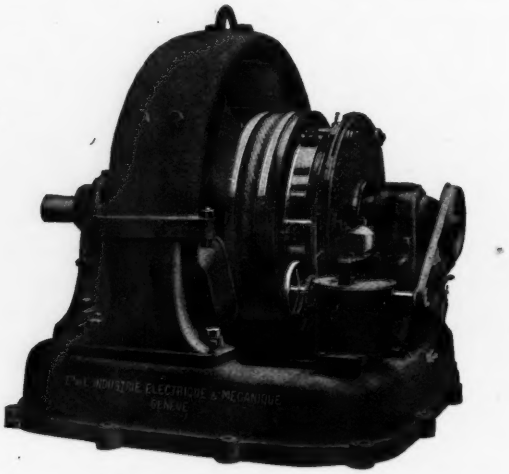


FIG. 5. DIRECT-CURRENT SERIES SYSTEM MOTOR OF 220 HP., 320 R.P.M., 3400 V., 50 AMP.

current machines with slip rings have an advantage. This is undoubtedly the most serious difficulty encountered in the production of satisfactory powerful units at high voltage with low amperage.

The first series machine made in 1890 was designed for a voltage of 1200 v. per commutator. In 1893, machines were made for a voltage of 3500 v. per commutator, and later 5000 v. per commutator. A voltage higher than 5000 v. has, up to the present time, not been exceeded in practice. With 5000 v. per commutator, 20 commutators are necessary to produce 100,000 v.

It is evident from the above that the present-day limit of 5000 v. per commutator means that the number of units to give a total high voltage is relatively great. This disadvantage, however, has one good point. In case of breakdown at any part of the plant it will only be necessary to shut down a small section. In a typical Thury installation, the generators have been working for 8 yr. at a rate of 18 hr. a day at full load without having to change the carbon brushes, and during a total of

24 yr. of service not a single commutator has had to be removed. The voltage of these units, however, was not as high as 5000 v., but something like 1600 v. per commutator.

Figure 4 illustrates a typical Thury generator equipped with an automatic regulator and designed for 170 kw., 375 r.p.m., 3400 v., 50 amp. Thury motors are practically of the same design as the generators, as may be seen in Fig. 5, which is an illustration of a series motor with automatic regulator, and designed for 220 hp., 320 r.p.m., 3400 v., 50 amp.

Each generator and each motor must have its governor, the generators to maintain constant amperage on the line and the motors constant speed. Two methods of governing the generators are employed, (a) by varying the speed of the generator groups or (b) by varying the position of the brushes should the speed be constant. In the first method, one governor alone automatically adjusts the speed of the generator groups according to the tension of the circuit. It works on the turbine nozzles by means of a ratchet and pawl device or is actuated by oil under pressure. The generators are then series wound with fixed brushes and without any regulating device. This method of governing is chosen when hydraulic turbines capable of running at low speeds with half the available flow of water produce the necessary power. To avoid the speed being reduced too far for small loads when the output varies greatly, it suffices to keep only the number of units running which the service actually demands.

Governing by moving the brushes is used when the construction of the turbine requires a constant speed or when the efficiency of the turbines at light load is of importance. In such cases, a double control is necessary, one for the speed and one for the current intensity.

Speed governors are those generally used, but they are not required to fulfill the conditions which are demanded of governors controlling alternators; thus, in the series system, the control of the speed can be approximative, the division of the load between several units being independent of the speed.

The groups of the central stations can run at speeds varying 10 per cent one from another without any inconvenience and the division of the load suffers in no way.—General Electric Review.

Maintaining Proper Voltage

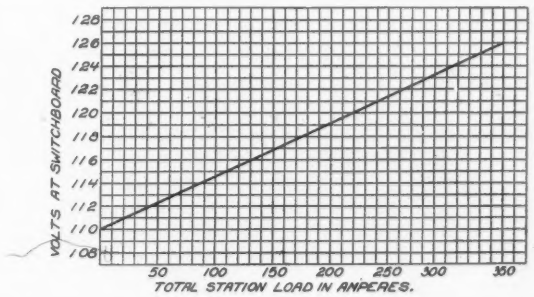
Curve Plotted from Voltage Readings Serves Purpose of Compensated Voltmeter

MANY power-plant designers and constructors fail to provide all of the necessary equipment and instruments which, if installed, would aid materially in rendering better service. This is especially true regarding the more general use of compensated voltmeters, by means of which it is possible to determine at the switchboard the value of the voltage existing at some distant points on the line, such as the center of distribution, so that, even though the proper voltage be maintained at the switchboard, that at the center of distribution is, during peak or heavy load periods, considerably below what is conducive to good service.

An operator may at times realize this to be true and will raise the switchboard voltage slightly to make up for the line drop; but as this is proportional to the load, he is at a loss to know just how much he should raise the voltage to compensate for this drop at any given load.

In a 3000-kw. power station located in Wisconsin, the chief engineer, some few years ago, hit upon a novel scheme to overcome this handicap so that, by referring to a curve plotted from a simple experiment conducted by himself, his operators were enabled to maintain the proper voltage at the center of distribution regardless of the load.

Having previously instructed his switchboard attendants to maintain a constant voltage of 110 at the board, he connected an indicating voltmeter at the point considered the center of the load and noted the readings of this voltmeter, at 15 min. intervals, from just before the heavy lighting load came on until midnight. From the 15-min. station ammeter readings as recorded on the log sheet, he was then able to determine the exact drop of voltage for a given load. Adding this drop to the station voltage, 110, he knew the value to which the station voltage should be raised in order to give 110 volts at the point of greatest load. These required station voltage values were then plotted on co-ordinate



BY FOLLOWING THIS CURVE, SWITCHBOARD ATTENDANT IS ABLE TO MAINTAIN PROPER VOLTAGE WHERE MOST NEEDED

paper against the total load giving a curve similar to that shown in the accompanying illustration. This curve placed in a frame and covered with glass was then hung in a conspicuous place on the front of the switchboard, so that when the attendant noted a total load of 100 amp., he knew by referring to the curve before him that in order to maintain the proper voltage where it was most required it was necessary for him to carry 114.5 v.

During the day, when the load did not, as a rule, exceed 50 amp., the station voltage was carried at about 110; but as soon as the peak load appeared, the switchboard attendant guided himself by the values shown on the curve. While this scheme may not come up to the advantages obtained from the use of a compensated voltmeter, it was found to serve the purpose surprisingly well.

In Commerce Reports, issued by the Bureau of Foreign and Domestic Commerce, are noted the opportunity for a manufacturer of leather belting to secure a representative in Russia, who intends to buy for cash. Weights, dimensions and prices to be given in Russian c.i.f. Russian ports. Also a firm in India wishes to get in touch with U. S. A. manufacturers of electrical supplies and accessories.

Design of Superheaters

FORMULA USED AND EXAMPLE PROBLEM SOLVED FOR DETERMINING SUPERHEATER HEATING SURFACE. BY WM. C. STROTT

ON various occasions, the writer has been asked what formula he uses in figuring the amount of surface required for a superheater under varying conditions of service. The subject is one which has not received the attention it should have, by writers on the subject. Their articles have mostly, so far, been only to give an exposition of the various types, their construction, application, etc.

For the benefit of those who might be glad to add a good formula to their Engineer's Pocket-Books, I offer the following, with an example to simplify its application:

$$X = \frac{10\,S}{2\,(T - t) - S}$$

Where

X = Square feet of superheating surface required per boiler horsepower.

S = Superheat required in degrees F.

T = Temperature of furnace gas at superheater.

t = Temperature of saturated steam at boiler pressure.

It is not often that the value of T can be readily obtained. For practical purposes it may be calculated from the following equation:

$$\frac{1}{(T - t)^{0.16}} = (0.172\,H + 0.294)$$

Where the value of T and t are the same as given above, and H is the percentage of boiler heating surface between the furnace and superheater, so that if there is 20 per cent of the boiler heating surface between the grates and superheater, then call H = 0.20.

Now, take the following example:

It is desired to find how many square feet of superheating surface is required for a certain boiler, carrying steam at 175 lb. gage. Let H, as given above, be 0.20. Now, from a steam table it is found that the temperature t of our formula of steam at 175 lb. pressure is 378 deg. F. Substituting in our formula for T we have

$$\frac{1}{(T - 378)^{0.16}} = 0.172 \times 0.20 + 0.294$$

$$\frac{1}{(T - 378)^{0.16}} = 0.3284; \text{ or } (T - 378)^{0.16} = \frac{1}{0.3284} \text{ or } 3.045$$

$$(T - 378) = \sqrt[0.16]{3.045}$$

$\sqrt[0.16]{3.045}$ must be solved by logarithms, as follows:

(log of 3.045) ÷ 0.16 = 0.483587 ÷ 0.16 = 3.022419

No. for log 3.022419 = 1053. Therefore,

T — 378 = 1053.

Let us suppose that we require 200 deg. of superheat, which means that the temperature of the steam on leaving the superheater is 200 deg. higher than that corresponding to its pressure. We can now finish the problem.

$$X = \frac{10 \times 200}{2\,(1053) - 200} = \frac{2000}{1906} = 1.049$$

or let us say, that 1.05 sq. ft. of superheating surface is required per boiler horsepower. If our boiler is a 200-hp. unit, then we shall require, under the existing conditions, approximately 210 sq. ft. superheating surface.

(In the Practical Reference Tables for this issue a chart is published, based on the formulas given by Mr. Strott, by means of which superheater problems may be solved without the use of mathematics.—Editor.)

A. S. M. E. Boiler Code Progress

THE most important work recently done by the American Uniform Boiler Law Society Committee is the conference with the Boiler Rules Commission in the State of Indiana. In some points there is conflict between the Indiana rules and the A. S. M. E. Code, and the Commission for Indiana has ruled that the Indiana law must govern.

Thomas E. Durban, Chairman of the Administrative Council of the Uniform Boiler Law Society, visited Indianapolis in December last for a conference on this subject. A discussion revealed the fact that when the law stating that the A. S. M. E. Code for boilers would be acceptable in Indiana was passed by the Legislature, it was understood by those offering the amendment that the ruling of the Industrial Board that the Indiana rules should prevail, was due to the fact that nobody had had time to compare the 2 codes. There is no disposition on the part of the Indiana Industrial Board to work a hardship on the Code, but under legal advice, they state that the ruling given out must stand. The Industrial Board has no power to change the law, and an act of Legislature is necessary.

The chief points of difference are, that the Indiana law makes no provision for plate boilers for heating purposes, and such a boiler must correspond to the Indiana Code for power boilers. The A. S. M. E. Code permits steel of lower tensile strength than 55,000 lb. being used, if desired, for heating boilers, but this cannot be done under the Indiana law. Since a large percentage of boilers built under the A. S. M. E. Code have plate of 55,000 lb. tensile strength, this does not bar Code boilers. Indiana law requires a fusible plug, while the A. S. M. E. Code says that it may be used.

The chief points at variance, as stated by the Industrial Board of Indiana, are that in Indiana diagonal braces are not to be welded; tensile strength of plate in any boiler is to be not less than 55,000 or more than 65,000 lb.; longitudinal seams are not to exceed 12 ft. in length on H. R. T. boilers; manholes are to be located as provided in Section 8 of the Indiana law; and fusible plugs are required in all boilers.

In regard to the support of boilers, the Indiana rules differ somewhat from the Code; but this does not bar a boiler built according to the A. S. M. E. Code, which the Industrial Board has ruled would be satisfactory.

The American Uniform Boiler Law Society has started campaigns for the adoption of the A. S. M. E. Code into law in Georgia, Kentucky, Louisiana, Maryland, Massachusetts, Mississippi, New Jersey, New York, Rhode Island, South Carolina and Virginia, and will appreciate the assistance of all interested parties in securing such enactment.

GAS POWER APPARATUS

Producers, Engines and Industrial Applications

Nordberg 200-hp. High Compression Oil Engine

IN large sizes, the Nordberg Manufacturing Co., of Milwaukee, Wis., builds Diesel engines of the Carels Freres type; but for moderate sized units, namely, 50 to 200 hp., the company builds a high compression oil engine designed to meet widespread demand for an engine as simple as a slide-valve steam engine. There are many small steam plants burning oil, where the fuel totals 2 to 4 lb. per hp.-hr. An oil engine delivers the power on 0.4 to 0.6 lb. of oil, but nevertheless is worthless to a plant owner unless it is simple and reliable and can be operated by an ordinary mechanic.

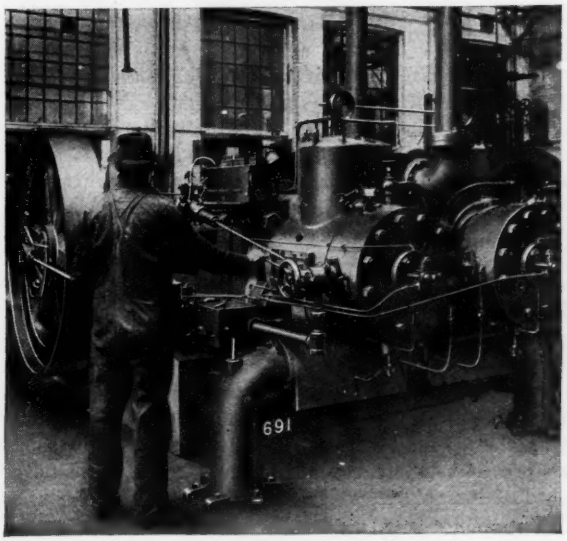


FIG. 1. SHOWING METHOD OF STARTING A NORDBERG 200-HP. OIL ENGINE

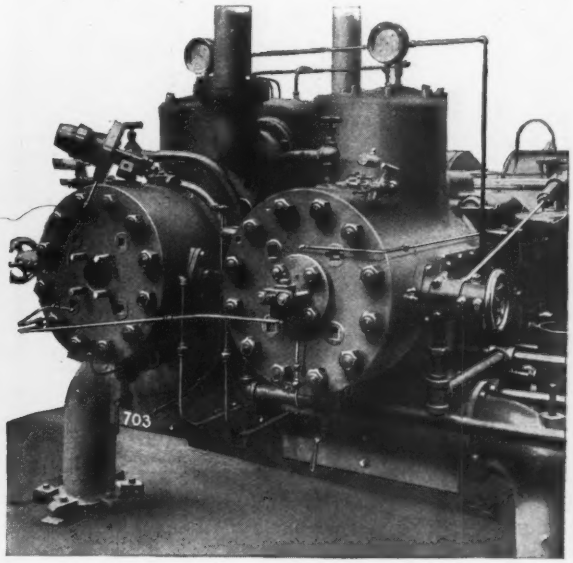


FIG. 2. CYLINDERS OF NORDBERG TWIN 200-HP. OIL ENGINE WITH ONE ATOMIZER HEAD REMOVED

The accompanying figures illustrate the 200-hp., 270-r.p.m. size, Nordberg high compression oil engine and details of starting gear and fuel pumps. These engines resemble Diesel engines insofar as concerns the method of ignition by the heat of the highly compressed air. The compression pressures are about 450 lb. But a 3-stage high-pressure air compressor for 1000 lb. pressure for injecting and atomizing the fuel is not used. The fuel is injected mechanically by a small pump and discharges through a new type of atomizing head which successfully subdivides and atomizes the oil. The success of the engine is due largely to the effective working of this atomizing head. The elimination of the high pressure compressor with its intercoolers simplifies the installation in small plants for which these engines are designed.

The engine is of the 2-cycle design, and all valves, cams, springs and valve gear have been eliminated contributing further to the item of simplicity and ease of attendance and inspection. The head is a simple symmetrical casting and is not subject to cracks due to unequal expansion strains. There are no valves in the head. The only valve on the engine is a piston valve for scavenging air located above and between the cylinders in the 200-hp. size here illustrated. One valve controls the scavenging air for the 2 cylinders. Air is compressed on the crank side of the piston and bypassed to the head end, shortly after the uncovering of the exhaust valves; this forces the burnt gases out of the cylinder and fills it with fresh air. Compression and combustion then occur as in any 2-cycle engine. The air intake is through the vertical pipes above the engine, and exhaust through the pipes going through the floor.

In the 200-hp. twin engine, a special automatic starting arrangement has been designed simplifying the operation so that the engine may be brought to speed in less than a minute.

Figure 1 shows the operator starting the engine by rocking an air valve which turns the engine over and at the same time throws in 2 auxiliary air cams which thereafter admit air at the proper points in the stroke, to each of the 2 cylinders. The starting air is furnished

by a steel tank previously charged to 250 lb. from a small auxiliary compressor. When the engine has come to speed one of the cams is thrown out by the corresponding finger shown near the top of Fig. 3, and at the same time the corresponding fuel pump is thrown into action by one of 2 levers on the same side of the engine, which may also be seen in Fig. 3. As soon as this cylinder fires, the air cam for the other cylinder is thrown out and the second fuel pump thrown into gear and the engine is then under control of the governor.

Figure 3 shows the details of the fuel pumps, which run in a bath of lubricating oil, the fuel levers and fuel governing mechanism. The oil is drawn from the storage tank to a small strainer box located to the right and behind the pumps, from which it flows to the main fuel pumps. A small heating coil, through which heated jacket water circulates, is contained in the main oil compartment of the strainer box to insure free flow of viscous oils. The pumps are operated by cams driven by an eccentric and deliver a quantity of oil in excess of

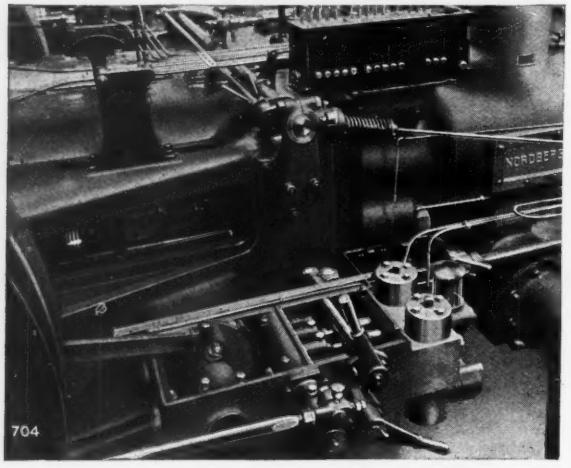


FIG. 3. VIEW OF FUEL INJECTION PUMPS, STRAINER TANK AND AIR STARTING GEAR

that required for maximum load, the governor acting to bypass more or less of the fuel depending on the load obtaining. The bypassed oil is discharged through the sight glass and gives the operator a quick check on the working of each of the pumps. The governor is of the well known flywheel design and gives a regulation of 2 per cent from no load to full load. From the fuel pumps the oil is discharged through small pipes to the atomizer heads bolted to the main cylinder heads, as shown in Fig. 1 and also in Fig. 2, where one atomizer head has been removed and placed on top of a cylinder. This device breaks up the fuel in fine particles and distributes it evenly over the entire section of the cylinder in the same manner as the fuel valve using highly compressed air in Diesel engines.

The lubricating system of the engines is entirely automatic, oil being fed from a central pump driven from the scavenging valve eccentric, shown in Fig. 3. Cylinder oil is pumped to the scavenging air valve and to the main cylinders. Bearing oil is pumped to all main bearings, to the crosshead pins through trombone oilers and to all auxiliary bearings. The cranks are enclosed by polished iron guards and the oil accumulates in the crank case from various parts of the engine and is drained to a filter and returned to the lubricator.

The photographs of the engine shown herewith were taken in the Test Department of the Nordberg Manufacturing Co., where permanent concrete testing blocks have been installed for each of the 3 sizes of high compression oil engine built. Before shipment these engines are given routine tests for economy and mechanical troubles.

To Test a Jump Spark Plug

By Arthur Phillips

IT is a well-known fact that the resistance to the passage of electricity of a compressed mixture of fuel and air is higher than of pure air at atmospheric pressure. This is shown by the fact that a spark will jump the gap in a plug when not under compression, but will not under some conditions do so if the pressure of the surrounding air is high. And it is at the point of highest compression, of course, that the spark is really wanted.

When a plug is removed from the cylinder, it is sometimes a little difficult to determine whether it will actually "spark" in the cylinder when it does so readily enough outside.

Obviously, if the resistance to the passage of the current between the points can be increased, conditions approaching those existing in the cylinder may be obtained. The first thought would be to spread the points to perhaps 2 or 3 times the normal gap. This, of a truth, may be done with good results electrically, but the bending of the points in this way will eventually cause the wire to break away and then the plug is more worthless than ever.

In trying to determine the cause of a bad-plug "epidemic" I had to test a number of plugs which had been pronounced "no good" to determine whether they were actually defective or really short-circuited. I hit upon the scheme of increasing the resistance between the points by another method Perhaps this has been used by someone previous to my use of it; but if so, I have never heard of it.

I slipped a small thin-walled test tube over the bent wire. Glass is one of the best non-conductors and insulators known. The current does not penetrate it. If the coil is sufficiently strong the current will jump from the middle electrode to the plug shell. If the plug is defective the current will leak through the defect. If it is short-circuited with carbon, the current may be seen to follow the carbon-covered surface of the porcelain. I have found it a very satisfactory method of testing plugs.

The heat of the spark adjacent to the thin glass wall eventually punctures it when, of course, the current passes through. A very thick piece of glass cannot be used, as this would necessitate the spreading of the points. Probably the best thing to use is thin sheet mica. This is as transparent as glass, not easily broken, and an excellent insulating material. Put a little piece in the tool box and the next time there is plug trouble, use it.—Gas Power.

LETTERS DIRECT FROM THE PLANT

Cash Paid For Ideas Accepted. Sketches Desirable.
We Make The Drawings

Be Prepared

FEAR OF the central station, which besets many an engineer of a small plant, often causes him hours of worry that could be better devoted to a careful investigation of the operating condition of the equipment under his supervision.

A case in point is as follows: A wood-working plant contemplated extensions that would require about twice the power that they were using. A 13 by 18-in. engine, rated at 125 hp., turning 200 r.p.m., was thought to be carrying full load. The question arose, whether a new engine should be purchased, or whether the additional load should be handled by central station service. The wood refuse was sufficient for the boiler, hence the coal-saving factor did not enter.

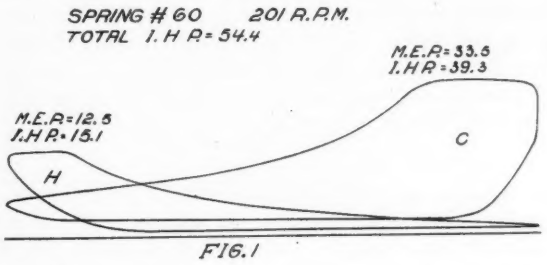


FIG. 1

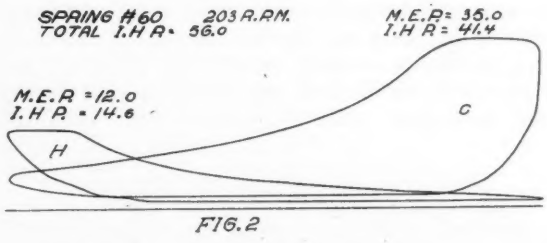


FIG. 2

FIGS. 1 AND 2. CARDS TAKEN FROM ENGINE BEFORE VALVES WERE SET

The engineer became anxious, and as he had been setting the valves by guess, he borrowed an indicator. Before ever a card was taken, simply opening first the head end valve and then the crank end, the sound of the escaping steam denoted trouble.

The first cards showed, as may be seen by Figs. 1 and 2—Fig. 1: A total of 54.4 i.hp., of which the crank end supplied 39.3 i.hp. and the head end 15.1 i.hp.; Fig. 2: A total of 56.0 i.hp., of which the crank end did 41.4 i.hp. and the head end furnished 14.6 i.hp. Needless to say, the engineer was careful that nobody outside of the engine room saw these cards.

At the noon-hour the valves were re-set and the results shown in Fig. 3 and 4 were obtained.

Figure 3: A total of 64.7 i.hp., the crank end supplied 31.3 i.hp. and the head end 33.4 i.hp. Figure 4: A total of 64.0 i.hp. crank end 31.5 i.hp. and head end 32.5 i.hp.

These last cards were shown to the management with some pride. It was decided that the engine was working well, and could easily take care of the additional load, since at no time would all the machines be in operation at the same moment.

It is safe to say, however, that had the central station plant test found the previous condition, it would not have taken a great deal of argument to convince the management that "the old engine is about done," and the proper thing would be to shut down the whole plant, and by putting the entire plant on central station service, earn the advantage of "less cost per unit of power by reason of a larger monthly power consumption, and thereby a greater discount for prompt payment of bill."

C. K. N.

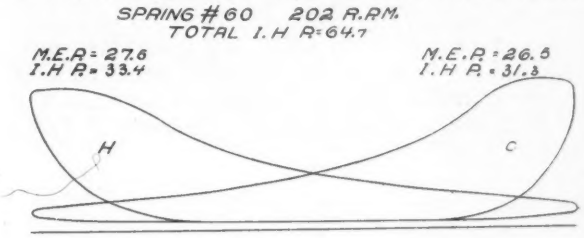


FIG. 3

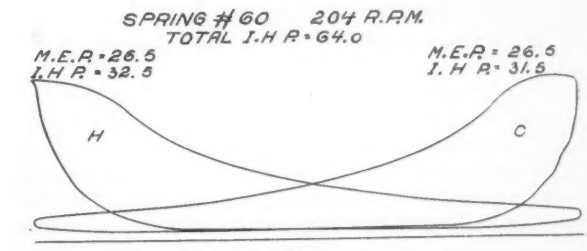


FIG. 4

FIGS. 3 AND 4. CARDS TAKEN AFTER FINAL ADJUSTMENTS

Lowering the Coal Bill

A FEW power plant necessities that are not in every power plant were lacking when the writer took charge of his present plant, 2 yr. ago.

One day the boss asked why the coal bill was $500 more the year just ended than the previous year. I suggested that he have scales and a water meter installed and perhaps I could tell him where some of the money went.

Without changing methods of operation after the installation of scales and meter, the boilers were checked up and an evaporation of from 6¼ to 7¼ lb. was shown. Cutting down the amount of coal fired from 4, 5 and 6 shovelfuls to a door to 3 brought the evaporation up to 7½ and 8 lb. of water per pound of coal. Then it was cut to 2 shovelfuls per door and the evaporation remained about the same.

Hard coal screenings and nut and slack are burned half and half mixture, with forced and induced draft, averaging $1.75 a ton. That year, the coal bill was $250 lower, with a 25 per cent increase in business.

It might be added, a flue cleaner was purchased and removed 400 lb. of scale from the 2 boilers; after this showing, it was not a hard matter to get a pressure recording gage, draft gage and kilowatt-hour meter. It was not hard to get a raise in wages, either. C. M. B

Engine Repairs

It is remarkable what conditions we find in plants that border on a "close call," yet somehow no serious calamity seems to happen. I once had the pleasure of assisting an engineer who had recently taken charge of an engine, which had been continually pounding on the head end. After putting on the indicator, I found that the valve rod had been lengthened as shown by Fig. 1; but this did not cause the pound, so I turned the engine over, making marks on the crosshead guide on each extreme of travel. Then I disconnected the connecting rod and, pushing it hard up against the head end, found

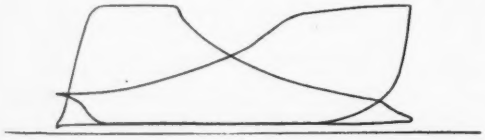


FIG. 1. CARDS SHOWING LENGTHENED VALVE ROD

that the crosshead only went even to the marks on the guides. This showed that there was no clearance, the piston hitting the head while the crosshead passed the crank end mark ½ in. This showed that the crank end had that amount of clearance and that the head end had none. Others, in trying to equalize this clearance, had put shims between the key and inner edge of brass box at A, Fig. 2; this, of course, did not equalize, but

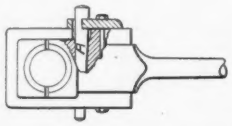


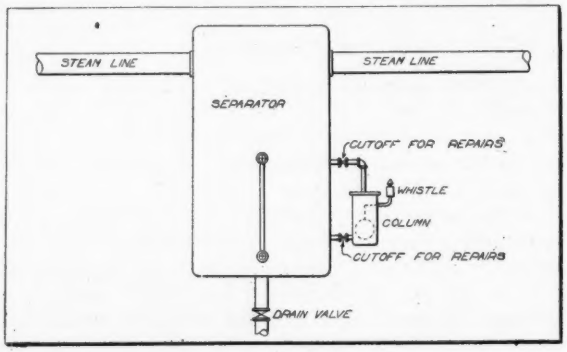
FIG. 2. OPEN END CRANKPIN BOX

simply raised the key or, as we say, gave more keyway, so they screwed the piston rod into the crosshead up to the last thread, which will do the trick for a while, but the time had now come when the proper method had to be used. I placed the shims in the outer end of the rod between the strap and outer brass box until the clearance became equal. A. C. Waldron.

High-Water Alarm for Steam Separator

Dangers of twisted valve stems and broken cylinder heads can, in large measure, be averted by the following scheme, which I have found to be a success.

To my engine separator I added a small water column which was equipped with a high-water alarm whistle. This column I placed near to the bottom and to one side of the separator. As the water level in the separator



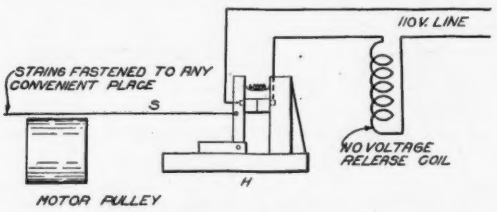
SEPARATOR PROVIDED WITH HIGH-WATER ALARM COLUMN

arose above the dangerous level, the alarm whistle gave its warning in plenty of time to avert any serious damage to the engine. This appliance will be found to be of particular value where a separator is not drained by traps and the engineer must depend on his memory to keep the separator drained. L. T. Mart.

Automatic Stop

In the accompanying illustration you will find an automatic motor stop to be used in connection with belting about to break or part at the joints.

The switch, H, is connected in series with the motor circuit and is placed at any convenient point so that a string, S, may be stretched from it at a height of about 1 in. over the belt, to some support on the opposite side. Then, for normal operation, switch H is closed with



AUTOMATIC MOTOR STOP

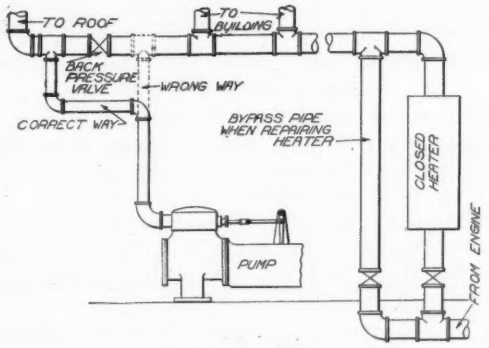
the string, S, taut. If a hook or a length of lacing should become loose, it will catch the string and tear it and in doing so, will open the switch. The switch being open and the flow of current stopped, the no-voltage release will operate and in turn the motor will stop.

A device of this kind will save many dollars, as, by its use, the attendant will be almost forced to make the necessary repairs before any extensive damage results. Mac.

Exhaust Piping for Pump

DURING THE SUMMER months a new pump was installed in our plant and worked to perfection until the cool weather set in, and then the pump commenced to act strangely, seeming to have hard work to perform its duty.

Looking for the trouble, it was found that the exhaust from the pumps was led into the exhaust main on the pressure side of the back pressure valve. Everything went fine as long as the pressure valve was open and all exhaust going direct to atmosphere. When it became necessary to send some of the exhaust through to heat building, the back pressure valve was closed for 5 lb.; result, 5 lb. back pressure on our pump. We changed exhaust from pump to atmospheric side of back pressure valve, as shown in accompanying sketch, and all was again O. K.



EXHAUST PIPING

It would seem any engineer should know better; but there is another plant near us with just the same trouble, but the engineer refuses to be convinced. W. T. H.

(Exhaust steam from a pump should be used if at all possible, as it contains almost as many heat units per pound as live steam at boiler pressure. W. T. H.'s piping marked "correct way" causes a direct loss. His pump should be proportioned to work against the necessary back pressure or piped to exhaust through a heater at atmospheric pressure. EDITOR.)

Remedying Economizer Leaks

WE HAD some difficulty with leakage around the headers in an economizer used to heat brine, and the readers of Practical Engineer may be interested in knowing how it was remedied.

First, let me say that most of the trouble was caused by marred header holes and plates, which was the result of unskilled labor at low wages. With perfect holes and plates, a tight joint might probably have been obtained simply by drawing the plate in.

We took 4 of the worst leaks for a trial and grooved these plates on a lathe ⅛ in. deep, leaving ridges about ⅛ in. wide on each side. Here and there, in a zigzag course, holes were drilled around the plate about an inch apart and ⅛ in. deep. Plates were then placed in wooden molds and lead poured around them, and after cooling they were turned down to their former size. Before being pulled into the header, the hole was painted with red lead, and the job proved very successful. The other plates were tightened with 100-lb. warm water pressure on the economizer, and everything proved all right except for the 4 mentioned above, which were tight after the treatment described. D. W. HOVEY.

Hunting Governors

SOME TIME AGO, I had trouble with one of our high-speed engines which did not run as steadily as it should. The voltage was steady, but there seemd to be a noise in the governor which sounded as it does when the load comes on suddenly; but, in this case, it occurred regularly every other revolution. The governor is of the Rites inertia type with a gag-pot, the plunger of which is connected to one end of the bar. The piston of this gag-pot has 2 ¼-in. holes drilled in it, and there is a bypass from one end to the other, with an adjusting screw. The oil used is cylinder oil and the adjusting screw in the bypass is usually left about halfway open.

On this occasion, the trouble was laid to the gag-pot, and upon examination it was found that the oil, due to long use, had leaked out around the rod and there was insufficient oil left to dampen the action of the governor. At another time, we had considerable trouble of the same nature with another governor of the same design. The cause, in this case, was that the oil had become too thick, due to long use, and did not let the governor work freely enough. When the engines were installed, different kinds of oils were tried in the gag-pots; but a lighter oil did not dampen the action of the governor enough to prevent racing. We found that better results were obtained by using a heavier oil and opening the bypass wider.

The writer has operated some Corliss engines on which the only way to adjust the sensitiveness of the governor was by removing or replacing screws in holes tapped in the piston. This is a good idea, and if the proper adjustments cannot be had with the number of holes already drilled, more can be drilled, which should be tapped out so that they may be closed up at any time if desired. This plan is better than putting in another piston. Usually a light grade of engine oil gives best results in the gag-pot of the Corliss engine. On one Corliss engine, the piston in the gag-pot had 2 ⅛-in. holes drilled in it, and there was a ¼-in. pipe bypass from one end to the other. This bypass had a valve in it which admitted of close regulation and, as the whole thing was nickel-plated, it presented a good appearance as well as giving excellent results, and could be adjusted while the engine was running.

It depends a great deal on the type of governor what grade of oil is used in the gag-pot. The Corliss governor is comparatively light and moves easily, and in order to get the proper regulation and at the same time prevent hunting, a light oil is used. In the Rites governor and some of its modifications, there is a greater mass of weight to control, and usually at higher speed, and the force to be dampened may be considerably greater than in the Corliss governor. This requires, in some cases, a heavier oil. On some of the governors of this type, the gag-pot sets at an angle to the inertia bar instead of perpendicular to it and, as the pull is not square with the bar but on an angle, this required a larger pot and heavier oil.

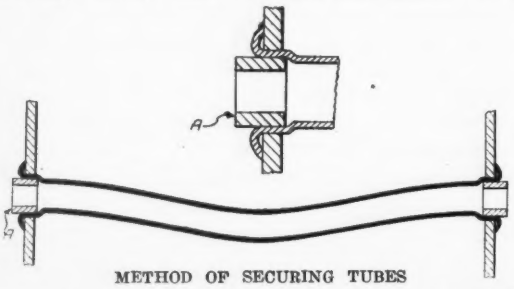
In the automatic shaft governor, the method of lubricating the eccentric frequently has a great deal to do with the action of the governor. On the high-speed engines above referred to, the eccentrics are lubricated with grease by means of spring compression cups. There always seems to be plenty of lubrication, but I do not think that the governor operates as quietly and as freely as it would if flooded with oil. In this case, however, changing from grease to oil would require a new type of oil guard, one that is enclosed on all sides to prevent throwing the oil on the floor and walls of the room. We are using Keystone No. 2 grease, which gives good results, though the first cost is high. Another and cheaper grease was tried; but when subjected to heat and wear, it formed a hard substance which worked into the oil ways of the cutoff eccentric, causing it to stick and produce dangerous racing. I find that when grease is being used, pouring on a little oil at intervals will "loosen up" the eccentric, as it were, and make it run more quietly; we do this about once an hour.

Grease is used on all parts of the valve gear with excellent results and is cleaner than oil. The main bearings, crank, crosshead, etc., are flooded with oil. Each engine has an individual oiling system, the bearings being supplied by a tank mounted on the top of the guides. The oil, after flowing over the bearings, goes to a filter at the base of the engine and is pumped back to the supply tank. I do not favor this system, as the room is warm and the oil is always hot and the bearings run very warm. The central gravity oiling system is best, as it insures a plentiful supply of oil which is cool and at good pressure, and the waste oil is given time to become properly filtered and cooled before being used again.

J. C. HAWKINS.

Yawning Boilers

THE BOTTOM row of tubes in a 7 by 20-ft. boiler did not expand the same amount nor at the same time as the shell, the distance between them being about 8 in. As the tube plate between the tubes and shell was rigid, the bottom row of tubes could not be kept tight. The beading would shear right off a new tube, when the shell expanded. The second row did not suffer so much. Have any of my fellow readers had similar trouble,



METHOD OF SECURING TUBES

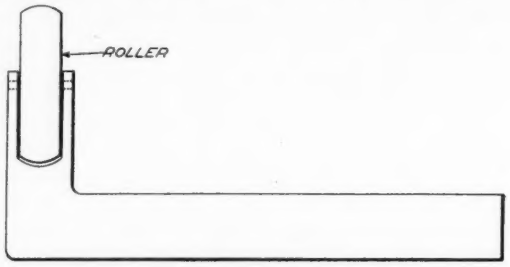
and what did they do and think about it? When boilers begin to gap and stretch themselves this way, one wonders when they mean to get up and walk away.

I cured this state of things by expanding the ferrules, A, into the bottom row of tubes at both ends, and afterward found that the tubes adapted themselves to the conditions by springing down in the middle under compression, as shown, and pulling out straight under tension.

H. K. SCHOLEFELD.

Babbiting Crankpin Boxes

WITH FURTHER reference to my communication on page 975 of the Oct. 15 issue and reply of S. J. Smith, on page 1099 of the Dec. 1 issue, I would like to state that I avoid altering the piston clearance by placing liners on both sides of the crank and wristpin boxes; however, should the clearance not be right after babbiting, I correct it by adjusting the journal boxes.



METHOD OF MOUNTING ROLLER WITH WHICH TO ROLL BEARINGS BEFORE TURNING

The method outlined in the Oct. 15 issue I have employed on a good many engines having rods attached to the crosshead by taper fit and key and in each instance have had good results.

If the box is to be bored, place a roller mounted as shown in the tool post of the lathe as in the accompanying illustration, and roll the babbit before turning. This answers the same purpose as peening.

A. L. JOHNSON.

Formula for Computing Rawhide Gears

RAWHIDE GEARS are computed mathematically just as metal gears are. They can be chosen to transmit a given horsepower at a given speed when meshing with a given gear very accurately. The usual formula, with good rawhide gears, as given by W. H. Diefendorf, is:

$$\text{Horsepower} = \frac{PD \times P' \times F \times \text{r.p.m.}}{850}$$

Where PD = Pitch diameter;

P' = Circular pitch in inches except where greater than 1.65 in.—that is, if the circular pitch is 2 in.—use 1.65 for P', etc.;

and F = Face of gear in inches.

Where lower grades of rawhide are used, the factor 850 must be increased to 1000 and sometimes more. The manufacturer can tell you just what factor to use in making your computations.

N. G. NEAR.

COAL, THE MAIN basis for power production, is certainly costly in Brazil. Welsh steam coal is quoted in Commerce Reports for Jan. 20, as $16.80 a ton delivered at wharf in Bahia in lots of 1000 T. or more and $2.40 a ton higher in small lots. Pocahontas coal is selling at $13.50 to $14 alongside vessel and gas coal at $15 a ton. Much wood is being used, due to these high prices for coal.

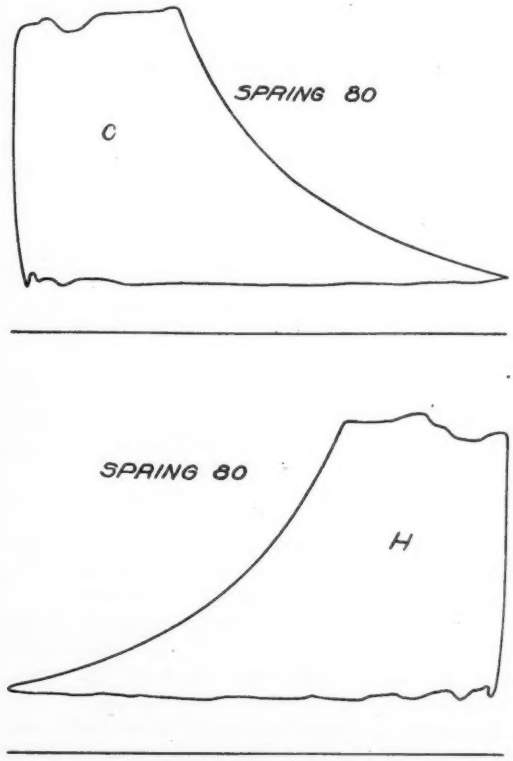
United States coal, which formerly was regarded with uncertainty, has shown up well under severe and thorough government tests and is now put on the same basis as Cardiff in tenders for government railway supply.

Questions Answered and For Answer

Expert Help When In Trouble. If You Want Quick Answer Enclose a Stamp

Indicator Card Criticism

THE 2 CARDS shown herewith were taken from a Vilter 12 by 24-in. ammonia compressor running at a speed of 50 r.p.m. The condenser pressure was 162 lb. per square inch and the suction 30 lb.



INDICATOR CARDS TAKEN FROM A 12 BY 24-IN. AMMONIA COMPRESSOR

I wish some of the readers of Practical Engineer would kindly study these cards, and send in their opinions together with suggestions to remedy the imperfections shown. E. H.

Fusible Safety Plug Trouble

IN A PLANT in Arkansas, trouble is experienced with fusible safety plugs in the boilers. After intervals of about 6 months, the plugs seem to be eaten away as if by electrical current from the inside, in some instances both filling and plug being affected.

Have any readers had a similar experience, and has a remedy been discovered? O.

Power Plant Problems

WHAT IS combustion?

2. What horsepower is required to pump 7000 gal. of water per minute to a height of 125 ft.?

3. The displacement of a piston is 7283.3 cu. in., and the length of stroke 36 in. What is the piston diameter?

4. On an ordinary steam engine, which leads, the crank or the eccentric?

5. How would you increase or decrease compression in the cylinder of a steam engine?

6. A pipe is 100 ft. high. What is the pressure in a 1-in. pipe tapped ½ way up?

7. In order to obtain smokeless combustion, what method of firing is to be preferred?

8. How can you tell when a water-gage glass is correctly fitted?

9. Why are small, closely spaced rivets used instead of widely spaced large ones?

10. Are the upper rows of tubes of a return-tubular boiler more efficient than the lower rows? D. P.

ANSWERS

COMBUSTION is the union of oxygen with some other element—usually in power practice, carbon. Hydrogen is present in small quantities. The 2 combine chemically at high heat, in case of carbon forming either carbon monoxide or carbon dioxide, depending on whether there is a sufficient amount of oxygen present, and in the second case forming water.

2. A gallon of water weighs 8.33 lb. The horsepower will then be found as follows: Multiply 7000 by 8.33, to give the total weight, by 125 to give the foot pounds per minute, and divide by 33,000 to give the horsepower, which is 220.5.

3. The displacement, in cubic inches, divided by the stroke gives the area of the piston; 7283.3 divided by 36 gives 202.5 sq. in., which from a table of areas of circles is a little over 16 in. diameter.

4. In the case of a direct-driven valve, where the valve moves in the same direction as the eccentric, the eccentric leads the crank.

5. Compression in a cylinder is increased by turning the eccentric ahead or by increasing the inside lap, and vice versa.

6. A pipe 100 ft. high, with a tap half way up, would have a pressure per square inch at the tap of 50 times 0.434, which would be 21.7 lb. per sq. in. The total pressure on the area of a 1-in. pipe would be this value times the area of a 1-in. circle, 0.785, or approximately 17.1 lb. If the 1-in. pipe is carried down to the base of the main pipe, the pressure at the base would be twice this, or 34.2 lb.

7. To get smokeless combustion, usually either coking or alternate firing is to be preferred. It depends largely on the kind of coal and the furnace with which you are dealing. In this matter, study the Jan. 1, 1915, Boiler issue.

8. The Ohio law calls for the following fitting of a water glass: The lowest visible part shall be above the fusible plug and the lowest safe water line. Automatic valves are not allowed, unless the boiler has gage cocks or other device for determining the water level independent of the water glass. The minimum size of pipes to the water column is 1 in. The water connections to be of extra heavy material, with crosses, tees and brass cleanout plugs. The steam connection to be from the top of the shell or upper part of the head; water connection from a point not less than 6 in. below the center line of the shell. No connections on the pipes leading from boiler to water column, except for damper regulator, feed water regulator, drains and steam gages.

9. Two things must be accomplished in the boiler joint: First, to keep the joint tight so that it can be calked to hold pressure; second, to hold the parts together. While the strength against tearing apart or shearing might be accomplished with the large rivets widely spaced, the edges of the sheet would buckle so that the pressure would leak through between the sheets.

10. On account of the sweep of the gases in the back chamber, there is a higher velocity of gases through the top tubes of a return tubular boiler than through the bottom tubes, so that they are usually more effective.

A. L. R.

Motor Problems; Ammonia Condenser Efficiency

WHEN RUNNING at full rated capacity, how many kilowatts per hour would a 35-hp. motor require? How would you in general calculate the horsepower of any motor of this type?

If a motor runs at less than full load, would it use less current? Would a variable speed motor running with reduced load operate with better efficiency than a constant speed motor under like conditions?

2. Is the double-pipe ammonia condenser more efficient than that of the atmospheric type? M. G. W.

ANSWERS

A HORSEPOWER is equivalent to 746 w., or 0.746 kw. For 35 hp. we would, therefore, have 35 times 0.746, or 26.1 kw. This would give in one hour 26.1 kw.-hr., but you must remember that the kilowatt, like the horsepower, is a measure of the rate of doing work, not a measure of energy. A kilowatt-hour is a measure of energy expended.

The value 26.1 would be the kilowatt equivalent of the output of the motor, and the current consumption would be larger, depending on the efficiency of the motor.

In regard to figuring the horsepower of an induction motor, if you have the measurement of the kilowatts input, divide this by 0.746, and it will give you the horsepower input. Then, the horsepower output would depend on the efficiency, which for a 35-hp. induction motor would probably be about 85 per cent, depending somewhat on the power factor. Any motor running at less than full load takes less current than if running full load. The current drawn is directly in proportion to the load carried.

There is no benefit in the variable speed motor over the constant speed, so far as efficiency is concerned. It is simply a matter of convenience of operation. As a matter of fact, in order to get a variable speed alternating-current motor, it is usually necessary to throw in some external resistance or induction coil, which will cut down the efficiency of operation.

2. In regard to the ammonia condenser, the double-pipe condenser is usually considered more efficient than the atmospheric type, because of the better contact secured of the cooling water against the ammonia piping. The only advantage of the atmospheric type is the ability of the condenser to evaporate some of the cooling water, the evaporated moisture being carried away by the air currents. The double-pipe condenser is, of course, more expensive than the atmospheric, but so far as efficiency is concerned, we do not believe there is very much difference, or that the water consumption would be materially affected. A. L. R.

Engine and Boiler Questions

How IS the horsepower of a reciprocating steam engine calculated?

2. How do you determine the number of expansions?

3. How is the steam pressure in the cylinder determined?

4. How do you obtain the length of stroke?

5. How do you obtain the speed?

6. How do you calculate the horsepower of a steam boiler? The bursting pressure? The water capacity?

ANSWERS J. R. G.

THE HORSEPOWER of an engine is equal to the product of the mean-effective pressure, in pounds per square inch, times the length of the stroke, in feet, times the area of the piston, in square inches, times the number of strokes per minute, divided by 33,000.

2. The number of expansions, more usually expressed as the ratio of expansion, is determined by dividing the volume corresponding to the piston displacement, including clearance, by the volume of the steam at the commercial cutoff, including clearance.

3. The best way of determining the steam pressure in the cylinder is with a steam engine indicator. We presume you wish to find the mean effective pressure, which is found from the indicator diagram as follows: Take a card of the engine, and then, either by a method of ordinates or by the use of a planimeter, find the area of the card. Divide this area, which should be in square inches, by the length of the card in inches, which will give you the average height of the card. Multiply this average height, in inches, by the scale of the spring used, and you will obtain as a product the mean effective pressure.

4. To get the length of the stroke, measure the travel of your crosshead. Turn the engine over so that the crosshead is at one extreme of its travel, then mark position on crosshead guide; now turn the engine over until the crosshead reaches the other extreme and also mark on guide. The distance between these 2 marks is the length of the stroke.

The length of the stroke is also equal to 2 times the length of the crank arm, that is, the length from center of crankpin to center of crank shaft. In the horsepower formula this must be measured in feet.

5. The speed of an engine, or the number of strokes per minute, when no speed indicator is handy, is best found by counting the number of strokes the engine makes in one minute. The number of strokes is equal to 2 times the number of revolutions.

6. The horsepower rating of boilers is usually based on the number of square feet of heating surface the boiler contains, and then allow from 10 to 12 sq. ft. per boiler horsepower. The heating surface of a boiler includes all parts of the boiler shell, flues or tubes which are covered by water on one side and exposed to hot gases on the other, the side next to the gases being used to measure the extent of the heating surface. Measurements are made of the inside area of fire tubes and the outside area of water tubes.

The bursting pressure of a boiler is determined by dividing the product of the tensile strength of shell plates, in pounds, times the minimum thickness of shell plates, in inches, times the efficiency of longitudinal joint, by ½ the inside diameter of the outside course of the shell or drum.

To get the safe working pressure, divide the bursting pressure by the factor of safety, which is usually taken as 5.

The number of cubic inches of water in a boiler divided by 231 gives the water capacity of a boiler in gallons or the number of cubic feet of water multiplied by 7.4805 will also give the capacity of a boiler, in gallons.

The method of finding the capacity of a boiler varies with the different types of boilers. We will give a few of the most common types.

For a horizontal fire-tube boiler, the volume is equal to the cross-sectional area of the inside of shell minus the area of segment above water level minus the cross-sectional area taken up by the tubes, multiplied by the length of the boiler.

For a horizontal water tube boiler, the volume is equal to the cross-sectional area of one tube times the length of tube multiplied by the number of tubes, plus the volume contained in each water leg plus the volume of the steam drum below water level.

For a vertical fire-tube boiler, the volume is equal to the cross-sectional area of shell minus the cross-sectional areas taken up by the tubes times the length up to the water line minus the capacity of the fire box.

For a vertical water-tube boiler, the volume is equal to the capacity of the lower drum plus the capacity of all the tubes plus the volume of steam drum up to water level. G. A. T.

Fuel Consumption Proportional to Load

WE HAVE an alternating-current series street lighting system using 6.6-amp. Mazda lamps and controlled by a Woods regulator. Part of these lamps are turned off after midnight.

Is there any saving of energy and fuel by turning these lamps out at the time specified instead of allowing them to burn all night?

2. Would 10 kw. at 110 v. be the same as at 2300 v.?

S. S.

ANSWERS

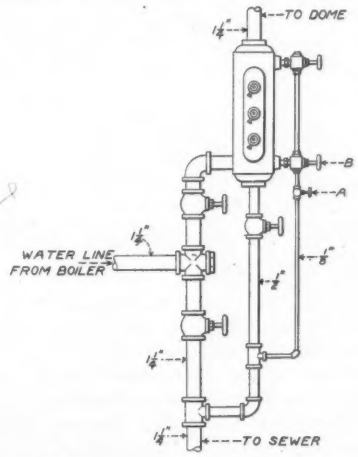
THE AMOUNT of coal burned in your plant will always be in proportion to the energy used, except for the change in efficiency of your generating machinery. When you cut out part of the lights on a series alternating-current system, while the amount of current remains the same, the voltage on the circuit is reduced automatically by the regulator. The energy used is proportional to the voltage times the current, so that if you reduce either voltage or current, you reduce the energy used, and therefore the coal burned.

2. Ten kilowatts will be the same, whether it is used on a 110-v. or 2300-v. The 110-v. will take approximately 20 times as much current to give 10 kw. as the 2300-v. A. L. R.

Cleaning Gage Glasses

REPLYING TO the inquiry of F. H. J. and J. H. H., I make my gage glasses clean themselves.

On the bottom gage glass fitting is usually found a small pet cock. This I removed and piped connections up as shown by the sketch. My method is, with all other valves set in operating position, open valve A



CONNECTIONS WHICH WILL FACILITATE CLEANING GAGE GLASSES

when nothing but steam will rush through the glass. Close valve B when alternate gusts of steam and water will pass through, washing the interior most thoroughly. When sufficiently cleaned, open B and A, and you have a clean glass for at least the next 24 hr. R. G. P.

IN CLEANING gage glasses we usually take a soft rag and saturate it with coal oil, close the valves and wipe the outside of glass. This method works very well here, as usually the glasses seem to be dirty on the outside only. We use Bishop's Adamant glasses and as they last over a year sometimes we had to find a way to keep them clean, and the above seems the best so far.

A. J. W.

Cleaning Injectors

I WISH some of the readers of Practical Engineer would please tell me how to clean the tubes of injectors effectively. SUBSCRIBER.

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Establishing a Standard Power Cost

What should be the cost of power in a given plant has long been and probably always will be the problem for the engineer in charge. He may be able to solve it to his own satisfaction, but to make the matter clear to the owner, who, most likely, is not familiar with the technicalities of operating a power plant, is by no means a simple task.

Many efforts have been made toward the standardization of power cost with varying degrees of success, but most of these methods have been based upon the average cost of power as it varies with size of the plant, cost of coal, type of principal equipment or other features of design. The result has been a confusion of ideas and data which has worked to the disadvantage of many plant owners.

Basing his method upon test data under operating conditions of the individual plant, Walter N. Polakov presents a method which appears to be the most logical yet devised. The outline of his method, as described before the A. S. M. E., is given on other pages of this issue, and while it lacks an immediate means for predetermining cost of power in a proposed plant, it gives what is at present more important, a means for studying operating conditions in any plant and comparing them with the ideal for that plant; application of the method in many plants would eventually give the long desired standard cost for plants of various sizes and types.

Complete records of operating data and costs, and the continuous test, and the systematic investigation of power plant losses are essentials to the successful application of the method presented. The engineer who has established these in his plant and worked out the most economical program of operation has gone a long way toward standardization of power cost in his plant; and with properly presented reports and curves showing relative variations, owners can judge how near the actual cost comes to lowest possible and why losses have occurred.

A Test Boiler

In the operation of any steam plant the question of fuel enters more than any other factor into the efficiency of the plant. Not only does this question have to be solved for each locality and plant, but, as mines are worked out and new mines are developed or transportation charges or routes change, the question requires continual study.

Our attention is called, at this time, to the method employed in the plant under consideration in the article under the heading "Efficient Operation of Boiler Rooms" in this issue. This plant was designed for and operated originally on anthracite coal. Deliveries, however, became of a lower grade, and the supply becoming short, prices went up. It was manifestly impossible to use bituminous coal alone in furnaces designed for anthracite and conform to the smoke laws of the city, so mixed fuel was experimented with. As a result of the investigation the fuel was selected and the furnace redesigned without materially altering the setting.

Much has been written on the subject of selecting fuel, but when all is said and done, the proper fuel is that which will produce power the cheapest, conform to

local anti-smoke laws and keep deterioration expense down. Elaborate chemical tests and determination of heat value will afford an engineer a means for predicting with reasonable accuracy what results will be secured from a coal, but investigation should not stop with an analysis nor should coal be selected entirely on an analysis.

One boiler, at least, in a plant, should be fitted up for test purposes, this should be run in conjunction with the others, and investigations carried out upon it will direct not only the selection of fuel but any changes in furnace design, baffling, routine of operation, etc., which should be made on the other boilers.

News Notes

THE AMERICAN MUSEUM of Safety has just announced through its President, Arthur Williams, that the Anthony N. Brady Memorial medals will be awarded to the Union Traction Co., of Anderson, Ind., for its excellent record in accident prevention during the year 1915. Arthur W. Brady, who is the president of the winning road, is in no way related to the late traction magnate in whose memory the medal was founded. Honorable mention this year goes to the Chicago Elevated Railroads, Britton I. Budd, president, which made the next best record to the Indiana company. The first award of the Brady Memorial medals was made in 1914 to the Boston Elevated Railroad. Dr. William H. Tolman, secretary of the Jury of Awards, the other members of which are Bion J. Arnold, James H. McGraw, George F. Swain, Will J. French and Frank R. Ford, states that the award to the Indiana road was based on accident prevention, not only among its own employes, but to the traveling public, on the sanitary conditions of its cars and shops and on the welfare and benefit work it is carrying on among its employes. The principal medal is of gold and is presented to the road. A replica in silver is presented to an operating chief and a replica in bronze to a workman in the shops or on the lines. The winners received the medals in person at the annual dinner of the American Museum of Safety at the Waldorf Astoria, Feb. 3, 1916.

THE VETERAN EMPLOYES ASSOCIATION of the Westinghouse Electric & Mfg. Co., at its Third Annual Banquet, held Saturday evening, Jan. 29, presented to the company a handsome bronze memorial tablet of the late George Westinghouse.

The memorial tablet is approximately 4 ft. by 3 ft., made of solid cast bronze, and weighs about 300 lb. It shows a true bas-relief likeness of Mr. Westinghouse, taken from one of his best photographic poses, seated in an armchair. It bears the inscription "GEORGE WESTINGHOUSE, Master Workman, Inventor, Founder, Organizer, 1846-1914." It will be placed in the reception room of the East Pittsburgh works of the Electric Co.

The model for this tablet was sculptured by Lorado Taft and was cast in bronze and placed in position by the Jas. H. Matthews & Co., of Pittsburgh, Pa.

Addresses were made by a number of veterans, former associates of Mr. Westinghouse, including E. M. Herr, president; L. A. Osborne, vice-president; N. W. Storer, general engineer; B. Kupferberg, of the store-room office; Chas. F. Scott, consulting engineer, and Guy E. Tripp, Chairman of the Board of Directors. Each speaker referred to some different phase of the great inventor's life, which has particularly impressed him.

The tablet was presented on behalf of the Veterans by Chas. F. Scott, who in addition to his duties as consulting engineer, is also Professor of Electrical Engineering, Sheffield Scientific School, Yale University, and was accepted on behalf of the company by Guy E. Tripp.

FROM A MAN in Colombia, S. A., the Bureau of Foreign and Domestic Commerce, Washington, D. C., has received an inquiry for catalogs, prices and full information on pumps, rams, gas engines, hot and cold water systems, etc. Details can be had from the Bureau.

HERBERT COWARD, who for 3 yr. has been in charge of the Spiro Turbine Department of Buffalo Forge Co., and for 4 yr. previous engaged in sales and engineering work in connection with air conditioning apparatus, has been appointed Steam Engineer of the Carrier Engineering Corporation, and is now located at the company's main offices, 39 Cortlandt St., New York.

BUREAU OF DOMESTIC AND FOREIGN COMMERCE reports that electric light bulbs and accessories are desired by a firm in Netherlands; that a firm in Canada wishes 15 gasoline engines, 1 to 20 hp., hopper cooled, for farm use, immediate delivery; an American exporter asks for electrical supplies, gasoline and kerosene engines and lubricating oils for introduction into China. Full details may be had from the Bureau at Washington or its district offices in the larger cities.

AN AMERICAN consular officer in China reports that a firm in his district is in the market for equipment for a complete electric lighting plant including water-tube boiler, surface condenser, 100-hp. engine at 400 r.p.m., 220-v., 60-kw. dynamo and 50,000 ft. insulated wire of various sizes. Addresses and further information may be had from the Bureau of Foreign and Domestic Commerce, Washington, D. C.

BEFORE an interested audience at the Pilgrim Publicity's Noonday Luncheon on Jan. 24, in talking of his recent experiences in Russia, Thomas W. Pelham said:

"The first impression one receives is the vastness of Russia, the magnitude of the still undeveloped market. Russia is in immediate need of goods. Her credit, while low at present, due to her inaccessibility, is really inexhaustible. Today thousands of tons of freight are tied up. The government comes first and the merchant has to wait. The bankers, however, will finance them to the limit.

"Prior to the war, the Russian business man was accustomed to the 'laissez faire' methods. Credit was extended 3 or 4 months; care was taken of all the details of transportation; for this the merchant was willing to pay.

"Today the feeling is vastly different. Mr. Merchant is awakening, he is more progressive and more liberal. American goods stand in high favor. Russians are looking toward us for increased supplies. The Russians want our goods, yet we must do business in their way. We must extend credit, establish agents and distributing centers."

Power Apparatus in Shop and Market

New Ideas In Making, Buying and Selling

Morse Shaking and Dumping Grate

THIS modern-design grate, made by R. F. Morse Co., of Providence, R. I., is of shaking and dumping pattern, having the bars carried by end trunnions in side frames, and moved to shake and dump by a shaker bar attached to arms on the under sides of the bars.

In flat position, a continuous grate surface is presented with 68 per cent of air opening. The back and forward rocking produces a cutting action on the ash and clinker by the ends of the cross clips which overhang the lengthwise trusses of the bars, thus keeping the fire free for circulation of air.

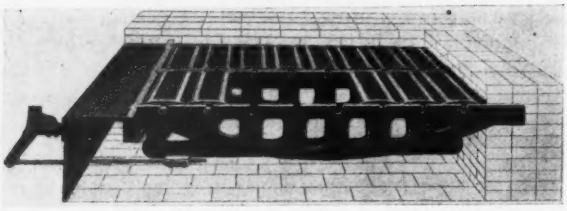


FIG. 1. MORSE SHAKING GRATE WITH PART OF BARS REMOVED

The bars are of the form shown, each bar having 2 lengthwise trusses which carry curved clips, these clips having a ¼-in. groove, or channel, running the full length on top. This groove collects ashes which save the metal from fusing and act as a nonconductor to insulate the bars from the fire.

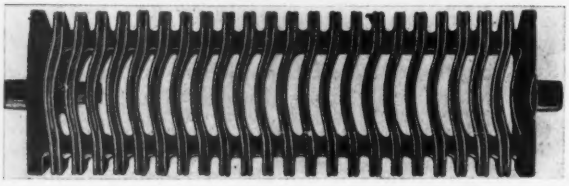


FIG. 2. FACE VIEW OF SINGLE MORSE GRATE BAR

Trusses and clips are beveled from the top side to the bottom, trusses tapering from ⅞ in. on top to ⅜ in. on bottom, and the clips from 9/16 in. face at the top to 3/16 in. at the bottom; space between clips on the face of the bar is ½ in., and at the bottom ⅞ in. This gives free drop for all ashes which may pass through the surface of the bar. It gives, also, a large opening on the under side of the bars for the upward passage of air.

Due to the shape of the ends of the clips, the space between bars is no greater when shaking than when locked level, so that fuel is not passed through except when the bars are thrown to the dumping position. The frame is constructed without bolts, all parts interlocking, care being taken in the design to prevent warping and to have all parts sufficiently heavy to withstand the required work.

The Radiator Trap "Sarco"

THIS trap, which is used on the return end of radiators for 2-pipe, low-pressure, vapor or vacuum heating systems, has connection at the left, as shown, for the radiator and at the bottom for the return main.

The operating force is obtained by expansion and contraction of a fluid sealed in the corrugated cartridge, which has on its lower end a piston carrying the valve head. When water collects, the liquid in the cartridge

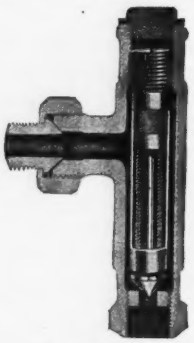


FIG. 1. CROSS-SECTION OF RADIATOR TRAP "SARCO," SHOWING CARTRIDE AND VALVE

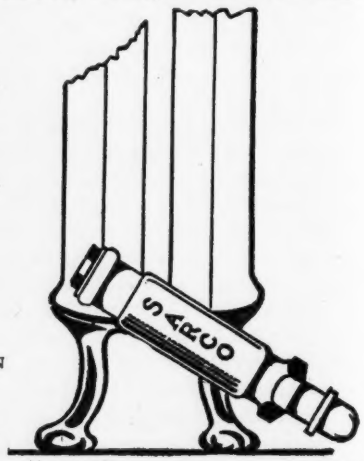


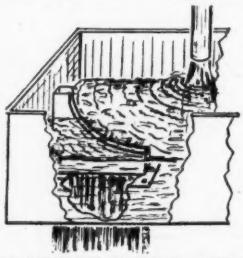
FIG. 2. RADIATOR TRAP "SARCO" ATTACHED TO RADIATOR AT AN ANGLE

contracts, drawing up the valve head and opening the trap for the discharge of water to the returns. As steam strikes the cartridge, the liquid inside expands, forcing the valve head downward and closing the discharge opening. This remains closed until water collects in the trap sufficient to condense the liquid in the cartridge and reopen the valve.

The action depends in no way upon the position of the trap, which can be set at any angle. The contact between head of valve and seat is a line, due to the conical form of the valve head, so that there is no surface on which scale or dirt can lodge. The distance between radiator and return line connection can be made either 3 or 1¾ in., as may be desired, according to the convenience of installation, the standard distance being 3 in. for the usual form of radiator, with return pipe passing down through the floor. This trap is made by the Sarco Engineering Co., So. Ferry Bldg., New York City.

Simplified Weir Measurement

IN experimenting to get accurate and simple measurement of the flow of water, Mr. Alger of The Kennicott Co., Chicago Heights, Ill., was impressed with the fact that, in common forms of weir, the flow through the rectangular notch is proportional to the 3/2 power of the head; through the V notch, to the 5/2 power of the head, and this requires, in order to read conveniently, flow registering apparatus to compensate for this law, so as to get uniform readings on the register scale.



FINAL FORM OF CYCLOIDAL WEIR NOTCH METER BOX

It occurred to Mr. Alger that taking a weir with rectangular notch, narrow in proportion to the height, and bending it outward so that the top of the notch would project beyond the edge of the weir, flow might be secured which would be in exact proportion to the head, so that the registering would be much simplified.

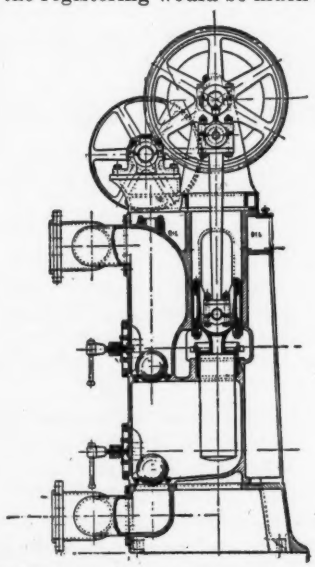


FIG. 2. CROSS SECTION OF BLACK-CLAWSON STUFF PUMP

After considerable figuring and experimenting, it was found that this could be done, and when the proper curve had been obtained, it was discovered that this was a right cycloid, that is, the curve which would be traced by a point on the circumference of a circle which was rolled upon a fixed line in the same plane.

Several meters were made and given careful tests, and the best results came from a form of metering weir shown in the illustration herewith. This is now made in cast form, box and notch being a complete unit, and machined by special jig which has been carefully worked out. The apparatus has been used in the boiler room of The Kennicott Co. for 1½ yr., and fundamental basic patents have been obtained covering this form of device.

Black-Clawson Stuff Pump

IN the design of the Black-Clawson long-stroke, heavy-duty stuff pump for use on paper and board machines of large capacity, accessibility has been made one of the principal objects. This refers particularly to the ball chambers, which are so constructed that any obstruction on the balls can be quickly removed without the use of a wrench.

Triplex pumps, similar to that shown in the illustration, can be used for either 1, 2 or 3 different kinds of stock, by removing the suction and discharge manifold, when each pump becomes independent. All stock chambers are of rounded section, making it easy to clean the pump quickly and thoroughly.

Plungers are made of cast phosphor bronze, extra thick, while the ball valves are also made of phosphor bronze, accurately machined and balanced, fitting in seats of the same material and are secured by bolts accessible from the outside and can be readily removed.

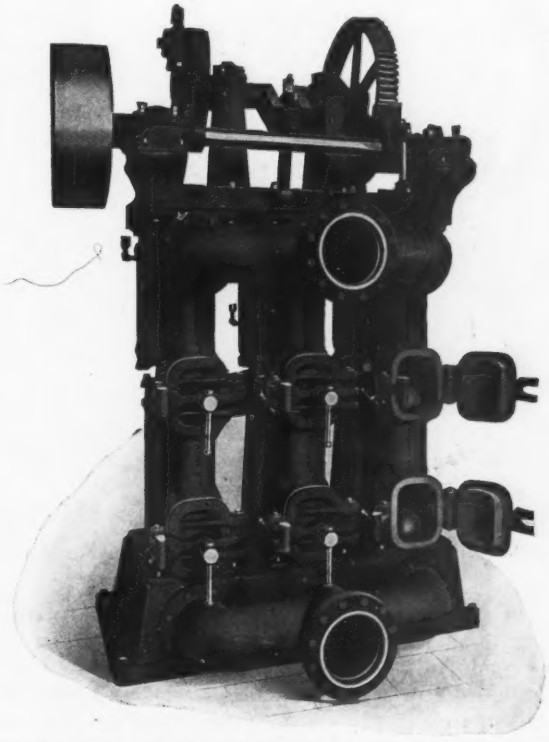


FIG. 1. VIEW OF BLACK-CLAWSON STUFF PUMP SHOWING ACCESSIBILITY OF BALL VALVES

Adjustable crosshead shoes are provided for taking up wear and operate in bored crosshead guides for which lubrication is provided from oil chambers cast in the frames.

Crank shaft and connecting rods are of cast steel, the connecting rods being 5 times the length of the crank. All bearings are bronze bushed, those on the connecting rod being of the marine type, fitted with sight feed oil cups.

These pumps are built by the Black-Clawson Co., of Hamilton, O., for working loads up to 120 ft. head.

Downie Deep Well Pumps

DOWNIE deep well pumps are made by the Keystone Driller Co., in single and double stroke type, the single stroke having a displacement polish rod so that part of the water is forced out on the down stroke. In the double stroke type a third crank, set at 180 deg. from the other two, is employed, working through a connecting rod and a crosshead operating in the same guides as the 2 outside crossheads, and giving motion to a second sucker rod working inside the first. Two water pistons with patent conical valves are used, one descending while the other ascends, giving a continuous discharge.

DOWNIE GEARED DOUBLE STROKE PUMP HEAD AND CONICAL VALVE WATER PISTON

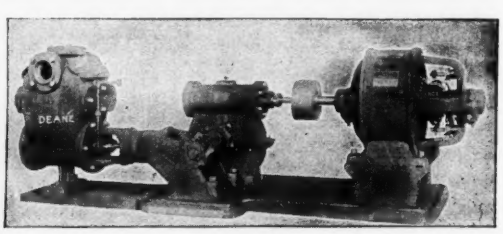
In the illustration is shown a geared double stroke pump head with an extended base plate which permits the pump to be braced front and back as illustrated. The lower crosshead and pitman rod are of cast steel while the crank shaft is of forged steel cut from the solid. The gears and pinions have involute teeth cut from the solid, the latter being of forged steel; the gear ratio is 6 to 1.

The length of each stroke is 18 in., making the displacement of water pistons 36 in. for each revolution of the crank shaft. All bearings are bronze and antifriction metal; the revolving bearings are fitted with sight feed oilers and the slides with dip pans. The countershaft is of machinery steel and is regularly furnished with balance wheel and plain belt pulley of suitable size to give the pump the required speed.

Pumps similar to that illustrated are made for wells 8 to 16 in. in diameter with capacities from 8492 to 37,013 gal. per hr. when working against a total head of 75 ft.

Quiet Pump for Heating System

RECENTLY, there has been installed in the new residence of Henry Ford, the automobile manufacturer, near Dearborn, Mich., a vacuum heating system in connection with which the pump shown in the illustration is used. In this system, a low working pressure throughout the entire heating system is made possible by introducing a vacuum in the return lines. This



VACUUM PUMPING SET FOR RESIDENCE SYSTEM

Deane 8 by 7-in. power vacuum pump marketed by the International Steam Pump Co., of Holyoke, Mass., takes care of the entire system, having about 10,000 sq. ft. of radiating surface. It is driven by a Westinghouse 7½-hp. motor through a worm drive which eliminates noise usually accompanying spur gear drive, and makes a very quiet operating pump suitable for residence and office work or other places where noise is objectionable.

Books and Catalogs

THE "MECHANICAL WORLD" POCKET DIARY AND YEAR BOOK for 1916; 264 pages; illustrated; Manchester, Eng., 1916. Price, $0.30 postpaid.

Noticeable and valuable additions to this, the twenty-ninth issue of this book are the subjects of Boiler Scantlings, Requirements as to Boiler Mountings, Notes on Brazing and Soldering and Tables Relating to Lancashire and Cornish Boilers, Dimensions of Locomotive Boilers, Steel Plates, Friction Clutches, Circle Spacing, etc.

The section on Steam Boilers has been largely rewritten and much new information introduced. In view of the prominent position of the Diesel Engine, a separate and enlarged section is now devoted to this type of internal combustion motor, embodying considerable concisely arranged data of general value to designers.

INDUSTRIAL USES OF FUEL OIL, by F. B. Dunn; 235 pages, 109 illustrations; San Francisco, 1916. Price, $3.

As the author states, this volume is intended to be a practical exposition of the use of fuel oil for industrial purposes. Not only is this subject discussed in connection with stationary, marine and locomotive boiler work, but also as applied to the clay, lime, cement, glass, sugar, rubber and metallurgical industries. Considerable space is also devoted to the use of oil fuel for domestic purposes.

Chapters I to V inclusive, consider the use of oil as a fuel, purchase, measurement, analysis and properties of the different oils, storage and pumping systems. boiler furnace arrangement, burners, strainers and heaters.

These tables contain data especially worked out or carefully selected that are vital to your work. You may need them at any time and should preserve them. A handy, serviceable, loose-leaf cover in which these tables fit exactly, will be sent you for 30 cents in currency or stamps

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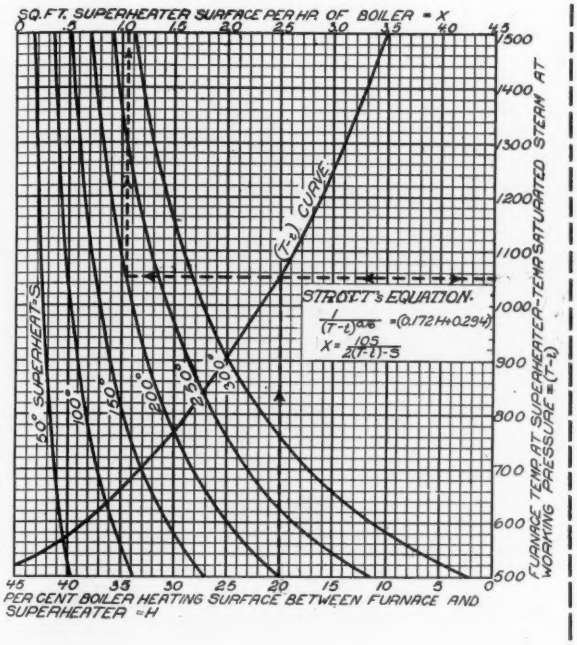
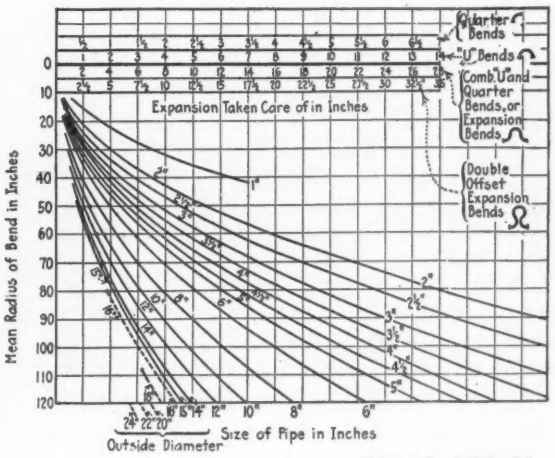
PRACTICAL ENGINEER

CHART FOR SUPERHEATER SURFACE


SQ. FT. SUPERHEATER SURFACE PER HR. OF BOILER = X
(T-t) CURVE
STROTT'S EQUATION.
$\frac{I}{(T-t)^{0.6}} = (0.172H + 0.294)$
$X = \frac{105}{2(T-t)-3}$
100° SUPERHEAT=S
FURNACE TEMP. AT SUPERHEATER-TEMP. SATURATED STEAM AT WORKING PRESSURE = (T-t)
PER CENT BOILER HEATING SURFACE BETWEEN FURNACE AND SUPERHEATER = H

PRACTICAL ENGINEER

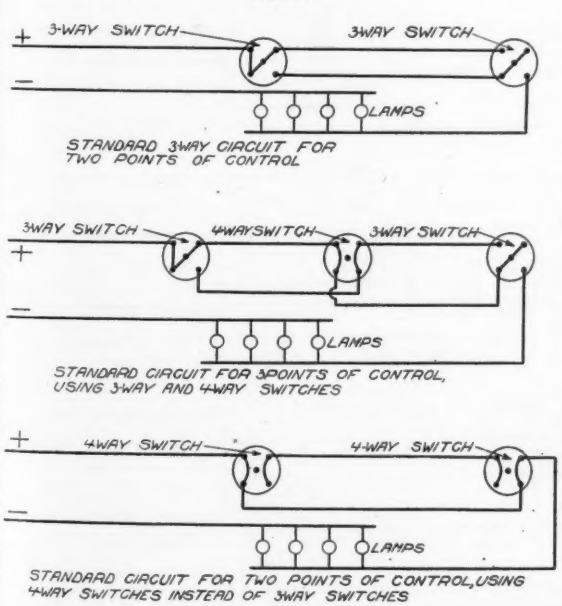
CURVES TO DETERMINE TYPE AND RADII OF BENDS TO TAKE CARE OF PIPE EXPANSION AND CONTRACTION


Quarter Bends
"U" Bends
Comb U and Quarter Bends, or Expansion Bends
Double Offset Expansion Bends
Expansion Taken Care of in Inches
Mean Radius of Bend in Inches
Size of Pipe in Inches
Outside Diameter

—Electrical World.

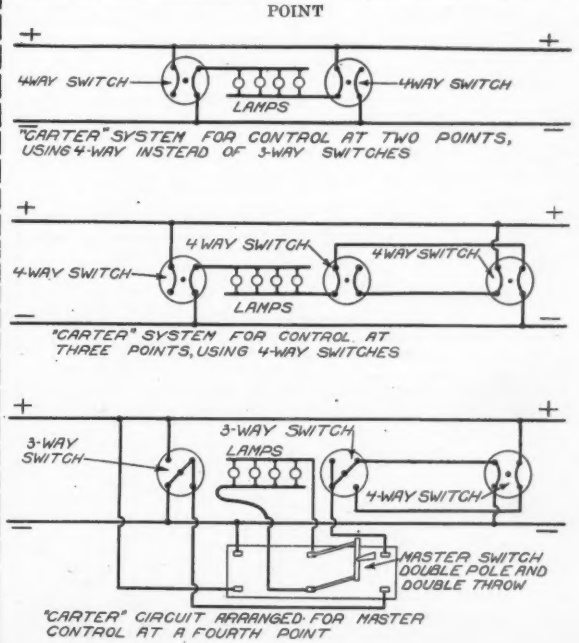
PRACTICAL ENGINEER

LIGHTING CIRCUITS CONTROLLED FROM MORE THAN ONE POINT



PRACTICAL ENGINEER

LIGHTING CIRCUITS CONTROLLED FROM MORE THAN ONE POINT


4WAY SWITCH
LAMPS
4WAY SWITCH
"CARTER" SYSTEM FOR CONTROL AT TWO POINTS, USING 4-WAY INSTEAD OF 3-WAY SWITCHES
4 WAY SWITCH
4-WAY SWITCH
4 WAY SWITCH
LAMPS
"CARTER" SYSTEM FOR CONTROL AT THREE POINTS, USING 4-WAY SWITCHES
3-WAY SWITCH
3-WAY SWITCH
LAMPS
4-WAY SWITCH
MASTER SWITCH DOUBLE POLE AND DOUBLE THROW
"CARTER" CIRCUIT ARRANGED FOR MASTER CONTROL AT A FOURTH POINT

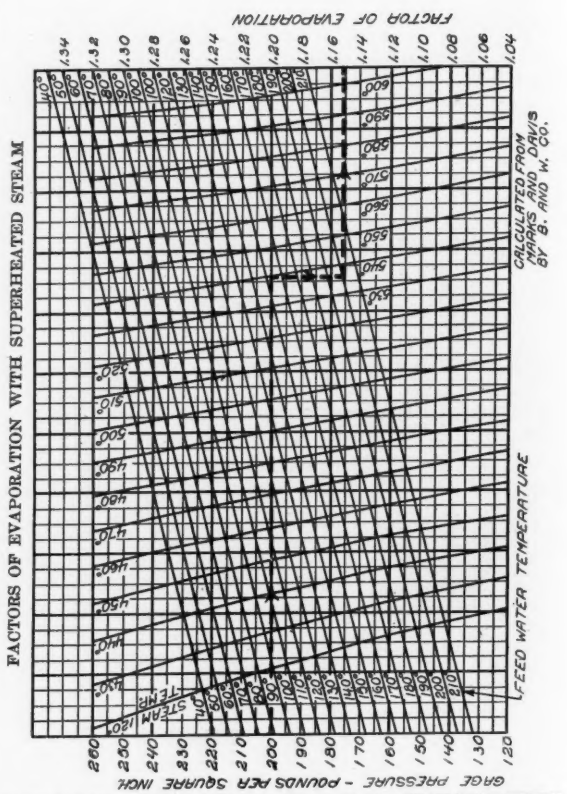
WEIGHT OF PIPE TO USE WITH DIFFERENT RADII OF BENDS, SIZES OF PIPE AND WORKING PRESSURES*

Size of Pipe (Diameter), Inches	0-125 Lb. Pressure		125-250 Lb. Pressure		250-350 Lb. Pressure
	4 to 5 Diameter	Over 5 Diameter	4 to 6 Diameter	Over 6 Diameter	4 Diameter and Over
7 and smaller..	Extra strong	Full weight	Extra strong	Full weight	Extra strong
8.....	0.5-in. thick	28.55 lb. per ft.	0.5 in.	28.55 lb.	0.5 in.
10.....	0.5-in. thick	40.48 lb. per ft.	0.5 in.	40.48 lb.	0.5 in.
12.....	0.5-in. thick	49.56 lb. per ft.	0.5 in.	49.56 lb.	0.5 in.
14 to 16.....	0.5-in. thick	$\frac{7}{16}$ in. thick	0.5 in.	$\frac{7}{16}$ in.	0.5 in.
18 to 22.....	0.5-in. thick	$\frac{1}{2}$ in. thick	0.5 in.	$\frac{7}{16}$ in.	0.5 in.
24 to 30.....	0.5-in. thick	$\frac{7}{16}$ in. thick	0.5 in.	$\frac{1}{2}$ in.	0.5 in.

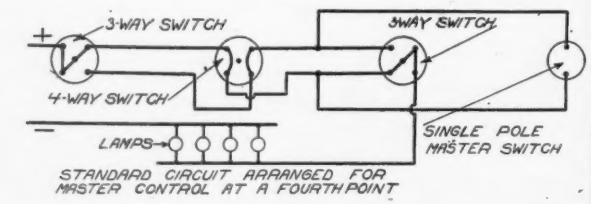
LENGTHS OF TANGENTS TO USE WITH BENDS MADE OF DIFFERENT SIZE PIPE*

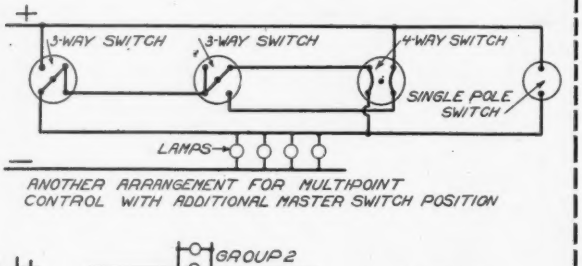
Sizes of Pipe, In.	Length of Tangent, In.	Sizes of Pipe, In.	Length of Tangent, In.
2.5 and 3	4	6, 7, 8, 9, 10, 12, 14, 15	16
3.5 and 4	5	7, 8, 9, 11, 12, 14, 16 to 30	18
4.5 and 5	6	... ..	..

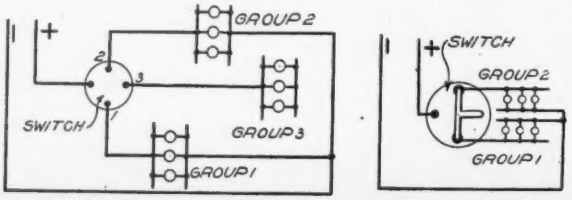
*Recommended by Crane Co.


FACTOR OF EVAPORATION
FACTORS OF EVAPORATION WITH SUPERHEATED STEAM
CALCULATED FROM MARKS AND DAVIS BY B. AND W. CO.
FEED WATER TEMPERATURE
GAGE PRESSURE - POUNDS PER SQUARE INCH
STEAM TEMPERATURE

LIGHTING CIRCUITS CONTROLLED FROM MORE THAN ONE POINT

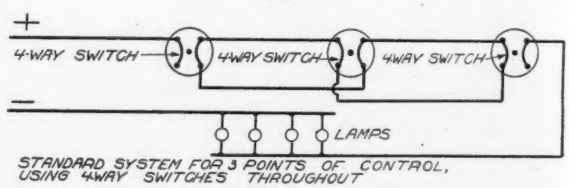


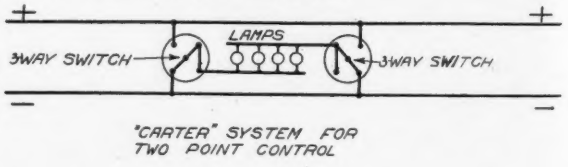


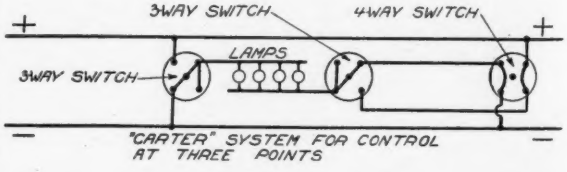


WIRING FOR ELECTROLIER SWITCHES

LIGHTING CIRCUITS CONTROLLED FROM MORE THAN ONE POINT







The matters of furnace efficiency and combustion, tests and reports, and the use of oil in gas making are taken up at length in the last 3 chapters.

The chapter on Tests and Furnace Efficiency should prove of special value to operating engineers, as it teaches how boiler losses may be checked and true efficiency determined. Engineers, architects, plant superintendents, fuel-oil salesmen and efficiency experts will also find matter of considerable value along their respective lines of work.

INVENTIONS AND PATENTS, by P. E. Edelman; 288 pages; New York, 1915. Price, $1.50.

As the author states, this volume is intended particularly for the layman and all persons interested in patents either as inventors, investors or manufacturers.

The various phases of the subject handled are: The Development of the Patent System; The Patent Office; Patent Attorneys; The Germs of Invention; The Fields of Invention; Preliminary Steps to Secure a Patent; Patentability and Practicability; Application for and Prosecution of a Patent; Protecting an Invention; Points of Patent Procedure; Patent Rights and How They Are Utilized; Disposing of Patent Rights; About Infringements; Points About Foreign Patents; Thoughts on Invention and Inventors; The Present Status of Invention.

CENTRIFUGAL PUMPS for all purposes, including condenser circulation, irrigation, drainage, dry docks and general mill and power plant service, for motor, engine or belt drive, are now being built by the Wheeler Condenser & Engineering Co., of Carteret, N. J., and are described in a new bulletin, 108-A. These pumps are of the single-stage, double-suction, split-casing type, for heads from 0 to 300 ft. Particular stress is laid in this bulletin on the testing facilities in the Wheeler hydraulic laboratory, provided with calibrated motors, gages and tanks with V-notch and rectangular weirs for measuring the quantity of water, and secondly, upon the accurate casting and machining of pump parts, particularly the impellers. A short description of foundry methods is given.

Among the designs of pumps shown, several are of particular interest, such as a combined motor and geared turbine-driven centrifugal pump, a typical complete surface condenser auxiliary, with geared circulating pump direct connected to turbo air and condensate pump driven from a common turbine, a large vertical shaft dry dock pump, etc. Several pages are devoted to vertical shaft pumps, and excellent illustrations show the design of the vertical thrust bearing with self-contained lubricating oil pump, of the lower self-lubricating guide bearing, and the design of impeller and casing.

CLING SURFACE CO. is distributing a calendar for engineers which shows a belt running with and without Cling Surface. The view was taken in the plant of the Woodbury Granite Co., at East Bethel, Vt., and H. V. Allen, the chief engineer of the company, on receiving a copy of the calendar wrote to the Cling Surface Co., as follows:

"I wish the picture showed the belt as it is today. It was only 18 in. slack when the photograph was made (it is 16 ft. centers), but now when many of the machines happen to shut down near together, causing the pressure to rise to 110 lb., the top side will sag down almost to the bottom—like a horse working hard to keep the load moving, seems to realize that it has got to get down and pull. It never slips nor shirks.

"It is amazing how little Cling-Surface is required after you are well started. This belt gets about one tablespoonful monthly, and our other belts in proportion. They are all in better condition today than they were 4 yr. ago.

"Mr. Havey, our superintendent, is very proud of the calendar belt and won't allow me to set the motor back, but I shall soon have to do something to keep the belt's sides from touching.

"Your new calendar is hanging in the office and we are all pleased to think our belt was thus honored. An old calendar of yours showing 3 different slack belts is still hanging there. Today, as we are looking at it, I said, 'Those belts have nothing on mine now.' 'No,' Mr. Havey said, 'and now we know that those were real photographs.'

"This is true. Before we got the company to buy Cling-Surface, we used to look at your circulars and really doubted that they were real photographic pictures of actual conditions of belts doing their work."

APPLYING THE X-RAY, one of the latest publications of Armstrong Cork Co., Pittsburgh, Pa., deals with insulating materials and illustrates a model refrigerating plant which was one of the features of the company's exhibit at the Panama-Pacific Exposition. Copies of this folder will be supplied by the company to all who are interested.

SQUIRES STEAM TRAPS, reducing valves, pump governors, boiler feed water controllers and gas regulating valves for steam boilers are described in a catalog lately received, which also gives dimensions and price lists. Illustrations show plants and steamers equipped with the company's steam specialties. The manufacturer is The C. E. Squires Co., Cleveland, O.

AS THE ANALYSIS of flue gases tends to develop better methods of firing, which in turn reduces waste of fuel, the Bureau of Mines, Department of the Interior, in Bulletin 97, "Sampling and Analyzing Flue Gases," by Henry Kreisinger, engineer, and F. K. Ovitz, assistant chemist, just issued, present for the benefit of those in charge of boiler plants and all other persons interested detailed information on methods of sampling and analyzing flue gases, and on the utilization of the analyses in promoting boiler-room economy.

This bulletin is intended to be a companion to Technical Paper 80, "Hand Firing Soft Coal Under Power-Plant Boilers," and is written in plain and nontechnical language, as far as possible, so that it may be readily understood by persons who have not had the advantage of a technical education. Whenever possible, illustrations of apparatus and methods of handling have been used rather than elaborate descriptions.

The material presented is arranged in 2 parts, the first containing the description of the apparatus and the methods used in sampling and analyzing flue gases, the second giving experimental results obtained with the different methods of sampling and collecting flue gas that are recommended in the first part of the report.

Only simple apparatus and methods are considered, as they are accurate enough to show the large heat losses due to the use of too much air, and are also accurate enough to indicate any incomplete combustion losses of economic importance. Those who wish to obtain information on the more accurate methods of analysis of gases are referred to Bureau of Mines Bulletin 12, "Apparatus and Methods for the Sampling and Analysis of Furnace Gases," and Technical Paper 31, "Apparatus for the Exact Analysis of Flue Gas," which may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., at a cost of 5 c. each. Bulletin 97 may be obtained by addressing the Director of the Bureau of Mines, Washington, D. C.

NIAGARA force feed mechanical oil pumps are the subject of circulars recently received. These are equipped with a ratchet driving device and can be connected at any angle, have vertical plungers, all wearing parts are immersed in oil; these and other features are discussed in the circulars. The manufacturer is The Niagara Lubricator Co., of Buffalo, N. Y.

Trade Notes

FOR THOSE dealing with internal combustion engines, determination of the action of the spark plug is frequently of importance and somewhat bothersome.

A convenient device, the Instanto spark plug tester, made by W. Jackson & Co., of Chicago, permits the testing of the plug without removing it from the cylinder, to determine whether it is sparking correctly or not.

A NEW BRANCH OFFICE has just been established at San Francisco by the Bristol Co., at 727 Rialto Bldg., and one of their sales engineers, B. J. Klein, has been appointed Pacific district manager and will have his head-quarters at this new branch office.

In connection with the extensive exhibit of Bristol recording and indicating instruments, set screws and belt fasteners at the Panama Exposition, great interest in the products manufactured by The Bristol Co., was evidenced by customers located in the Pacific Coast territory and the new branch office has been established in order better to serve the interests of these customers.

Mr. Klein is a mechanical engineer and instrument expert, having had a long experience with The Bristol Co., including a period of more than 6 yr. as Chicago District Manager, and having been located at San Francisco a year as manager of the company's exhibit at the Panama Exposition.

EDWARD F. HASSON, who was for 5 yr. manager of the General Specialty Co., Buffalo, N. Y., has become associated with the Advance Machinery & Supply Co., of Denver, Colo., as advertising and publicity manager. A newly organized service department will also be under his supervision. The above-mentioned concern are jobbers and manufacturers' sales agents covering the Inter-Mountain territory. Among those they represent are Nelson Valve Co., Yarnall Waring Co., Philadelphia; Ohio Blower Co., Cleveland; Fisher Governor Co., Marshalltown, Iowa; Duryea Mfg. Co., Wm. Andrews, Inc. (Deoleizer); Sarco Co., Inc.; F. C. Farnsworth Mfg. Co., New York City; Flexible Steel Lacing Co., Economy Fuse Co., Cochran Pipe Wrench Mfg. Co., Chicago, Ill.

PRACTICAL ENGINEER

Trade-mark, Reg. U. S. Pat. Off.

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POSITION WANTED—As Electrician and Engineer. Am experienced in installing, maintaining and repairing in steam heating, A.C. and D.C. plants. Desire to take charge where improvements will be welcomed. Address J. F. K., 877, 10th Ave., Milwaukee, Wis. 2-1-1

POSITION WANTED—As Boiler Room Superintendent by licensed engineer, familiar with boilers, water softening and CO_2 analysis. Strictly sober and reliable. Address Practical Engineer, Box 420, Chicago, Ill. 2-1-1

POSITION WANTED—As chief engineer. Have had extensive experience in operating, overhauling and erecting ice making, packing house and cold storage plants. Efficient and economical. Best results assured. Can furnish A1 references. F. J. Baumann, 511 East 84th St., New York, N. Y. 2-1-1

POSITION WANTED—By man who has made steam engineering a life study; have had several years' experience; at present am student in Complete Steam Engineering course with I. C. S. Would like position as engineer, assistant or oiler, with reasonable salary to start, and where I can advance according to merits. Age 26. Address Practical Engineer, Box 419, Chicago, Ill. 1-15-2

POSITION WANTED—Young man wants position as helper and extra engineer in steam plant for a start. Other particulars answered by letter. Write W. D. Bellesfield, Rock Valley, Iowa. 2-1-1

POSITION WANTED—As Chief Engineer. Am qualified to take full charge of power plant, A.C. or D.C., also refrigeration. Age 30. Married. Employed. Chicago only. Address Practical Engineer, Box 421, Chicago, Ill. 2-1-1

POSITION WANTED—Sales engineer with wide experience in selling Engines, Boilers and Steam and Power Plant Specialties. Thorough mechanic, technically educated. Have developed commercial ability. Address Practical Engineer, Box 423, Chicago, Ill. 2-15-1

POSITION WANTED—Engineer wants position in light plant. Experienced with producer gas engines, A.C. and D.C. machines. Technical graduate. No habits. Prefer plant with natural gas engines. Address Practical Engineer, Box 424, Chicago, Ill. 2-15-1

Help Wanted

WANTED—Resident subscription agents in the following cities: Atlanta, Ga.; Cincinnati and Columbus, Ohio; Kansas City, Mo.; Los Angeles, Cal.; Louisville, Ky.; Newark, N. J.; New Orleans, La.; Portland, Ore.; St. Louis, Mo.; San Francisco, Cal.; Washington, D. C. This is an excellent chance for a hustler, who is familiar with power plant conditions, to turn his spare time into dollars. To such a one we offer a Real Opportunity. Write Subscription Department, Practical Engineer, 537 S. Dearborn St., Chicago. tf.

FREE ENGINEER BOOKS and power plant tools and specialties for securing new subscribers to Practical Engineer. A dandy chance for the engineer with a little spare time to get some fine premiums. Send for free descriptive circular and terms. Address Practical Engineer, Subscription Department, Chicago, Ill.

WANTED—Central Station Engineer, Kentucky town, three units, total capacity 350 K.W. Also city pumping plant with filtration system. Must be thoroly competent to handle A.C. station equipment and know how to get results. Address Practical Engineer, Box 425, Chicago, Ill. 2-15-1

WANTED—A man successful in the selling of power plant specialties to handle an old established line on a commission basis. Address with complete details as to experience, references, etc. Address Practical Engineer, Box 426, Chicago, Ill. 2-15-1

Wanted

WANTED—Agents handling engine and boiler-room specialties in every section for side line paying large commissions. Give experience, line carried and territory covered. Address Practical Engineer, Box 381, Chicago, Ill. tf.

WANTED—Agents on commission to sell our Shaking Grates. We will install grates on trial or put it on test at our expense with any grate made. Address Armstrong Mfg. Company, Springfield, Ohio. tf.

For Sale

BOILERS: (two) 250-hp. Heine water-tube boilers, 150 lb., $950 each; (four) 300 hp. Sterling water-tube boilers, 150 lb., $1100 each; (one) 500-hp. Sterling water-tube boiler, 200 lb., $1750. 110-volt lighting dynamos, General Electric make, 30-kw., $200; 25-kw., $175; 20-kw., $160; 14-kw., $140; 9-kw., $100. Duzets & Son, 50 Church St., New York, N. Y. tf.

FOR SALE—15-H.P. combined tandem gasoline engine and air compressor. Used only two weeks. Can be operated as gasoline engine or air compressor alternately; 67 cu. ft. free air displacement. Weber Subterranean Pump Co., 90 West St., New York. 2-1-2

FOR SALE—AT RECEIVER'S SALE. A fully equipped machine shop in operation at Wooster, Ohio. This business has been in operation continuously for twenty years and has never been suspended. Dimensions of building 304 ft. by 111 ft., basement 25 ft. by 304 ft. Brick and steel construction. Built four years ago at cost of Eighty-two Thousand Dollars. Six acres of land on main line of The P., F. W. & C. Ry., with interchange to B. & O. Ry. Switch into factory. Eighteen lathes, nine drill-presses, eight planers, eight boring mills, four milling machines and all other machinery necessary to the equipment of a modern machine shop. Pattern shop and brass foundry included. Annual repair business about Thirty-five Thousand Dollars. About Fifty Thousand Dollars worth of finished, partly finished product and raw material. Also about Twenty Thousand Dollars worth of bills, accounts and notes receivable. (The material on hand and bills and accounts receivable vary from time to time, but anyone interested can get statement for any particular time or can investigate for himself on the ground.) This has been used as a steam pump factory, but is suitable for any other line of general machine works. Wooster is a town of eight thousand people, free from labor troubles, with ideal living conditions, in good gas fields, with six banks and loan companies, total deposits about Six Million Dollars. This plant, equipment, material and accounts ordered sold by the court as a going business March 1, 1916, at 1:00 o'clock at door of Court House, Wooster, O. Plant must be seen to be appreciated. Chance to buy splendid business at less than half its real value. Clerk of Common Pleas Court, Wooster, O., can give information as to inventory on file. R. L. Adair and W. H. Ross, attorneys for receiver, will give any desired information.

FOR SALE—Stokers: Two new "Crowe" Chain Grate Stokers suitable for 150 to 200 H.P. Boilers. 1/3 original price. Never used. Taken in exchange. The James A. Brady Foundry Company, Chicago, Ill. 2-15-4

Patents and Patent Attorneys

PATENTS THAT PROTECT AND PAY—Advice and books free. Highest references. Best results. Promptness assured. Send sketch or model for search. WATSON E. COLEMAN, Patent Lawyer, 624 F St., N. W., Washington, D. C. tf.

IMPROVEMENTS WANTED—Send for Free Bulletins listing manufacturers wants and book "Inventions—Patenting and Promoting." Lancaster and Allwine, 292 Ouray Building, Washington, D. C.

PATENTS—C. L. Parker, Attorney-at-Law and Solicitor of Patents. Patents secured promptly and with special regard to the legal protection of the invention. Handbook for inventors sent upon request. Washington, D. C. tf.

PATENTS—H. W. T. Jenner, Patent Attorney and Mechanical Expert, 606 F St., Washington, D. C. Established 1883. I make a free examination and report if a patent can be had, and the exact costs. Send for full information. tf.

A. P. CONNOR, Consulting Electrical and Mechanical Engineer. Attorney-at-Law and Solicitor of Patents and Trade-Marks. Results guaranteed. 121 Carroll St., S. E., Washington, D. C. tf.-x

PATENTS—Send sketch for free search and reports. Books on patents and book of reference letters sent free. John S. Duffie & Co., 612 F St., Washington, D. C. tf.

PATENTABLE IDEAS WANTED—Send for three free books. R. B. Owen, 28 Owen Bldg., Washington, D. C. tf.

Miscellaneous

ENGINEERS, DO YOU WANT to utilize your exhaust steam for heating or drying purposes, without back pressure on your engine? If so, address Monash Engineering Co., 1413 W. Jackson Blvd., Chicago, Ill.

Inventions

INVENTIONS commercialized on cash and royalty basis. Inventors and manufacturers should write Adam Fisher Mfg. Co., 2175 Railway Exchange, St. Louis, Mo. tf.

Sparks From The Advertising Pages

Know Your Plant

Men—know your plant if you would operate it at the highest efficiency—know the integral parts that make up the complete installation. Then know the construction and principle of operation of each one of these parts.

It is frequently the case—though it seems quite a paradox—that the men who are literally running the machinery know less about its details than those who are filling an official capacity such as the chief engineer, master mechanic, superintendent, etc. True enough, it is the business of the chief engineer and master mechanic to know all this, but if knowing it has helped them, might it not be a good plan for the undergraduate to study up on this phase of power plant operation. It would at least be a stepping stone to greater accomplishments.

If you are a chief engineer well worthy the name, or if your ambition is to fill that capacity you must know your plant from cellar to roof. The pipe lines must be charted on your mind as the ocean by-ways are outlined on the mariner's chart. You must know where the valves are situated—you must know the weak places.

You must know absolutely the condition of your boilers—how much you can force them without endangering life and property—you must know how long a given quantity of coal is going to last and you must be able to figure it almost to the hour.

You must know that the piping system was designed to take care of emergencies, as for instance, if a valve breaks on the main header the automatic stop valve on the boilers would shut off the steam before it would be likely to injure any of the men. You must know that if one of the valves on the compound condensing Corliss engine went "to the bad" at 7 P. M. you can run 3 legged during the rest of the night because your records have shown that at that time there is always a lighter load.

You must know the make of the lubricators—the valves—the regulators, etc., and where duplicates can be secured when necessary. You must know where the trouble is when the the steam pressure does a snake-dance on the recording chart. In short, you must know all that should be known to secure a smooth-running, efficient and economical plant.

Next to knowing your own equipment you must know what goes into the modern plant so that you will be posted on the possibilities of bettering your own plant should the opportunity present itself. A thorough knowledge of equipment is never superfluous to any engineer.

The machinery of yesterday, acceptable as it was for that time, will not compete with the machinery of today, therefore, you should know what goes into the 1916 plant—even down to the small details.

So to you, chief engineers—and to you embryo chiefs—let us say emphatically—read the advertising pages every issue—for the good of your plant—for the good of yourself—for the good of your profession.